Grantham Research Institute on Climate Change and the Environment

ENERGY FOUNDATION 能源基金会

China's role in accelerating the global energy transition through green supply chains and trade

Lei Bian, Simon Dikau, Hugh Miller, Roberta Pierfederici, Nicholas Stern and Bob Ward

Policy insight

February 2024

Grantham Foundation for the Protection of the Environment

The Grantham Research Institute on Climate Change and the Environment was established in 2008 at the London School of Economics and Political Science. The Institute brings together international expertise on economics, as well as finance, geography, the environment, international development and political economy to establish a world-leading centre for policy-relevant research, teaching and training in climate change and the environment. It is funded by the Grantham Foundation for the Protection of the Environment, which also funds the Grantham Institute – Climate Change and Environment at Imperial College London. www.lse.ac.uk/grantham

Energy Foundation China is a professional grant-making charitable organisation registered in California, United States. It started working in China in 1999 and is dedicated to China's sustainable energy development. The foundation's China representative office is registered with the Beijing Municipal Public Security Bureau and supervised by the National Development and Reform Commission of China. Its vision is to achieve prosperity and a safe climate through sustainable energy. www.efchina.org/Front-Page-eAbout the authors

About the authors

Lei Bian is a Policy Fellow at the Grantham Research Institute on Climate Change and the Environment.

Simon Dikau is a Distinguished Policy Fellow at the Grantham Research Institute on Climate Change and the Environment.

Hugh Miller is a Policy Analyst at the Organisation for Economic Co-operation and Development (OECD) and a Visiting Fellow at the Grantham Research Institute on Climate Change and the Environment.

Roberta Pierfederici is a Policy Analyst and Research Advisor to Professor Stern at the Grantham Research Institute on Climate Change and the Environment.

Nicholas Stern is the IG Patel Professor of Economics and Government, and Chairman of the Grantham Research Institute on Climate Change and the Environment.

Bob Ward is the Policy and Communications Director of the Grantham Research Institute on Climate Change and the Environment.

The names of the authors are listed in alphabetical order.

Acknowledgements

The authors would like to thank Chunping Xie, Zhifu Mi and Yihao Li for their helpful comments on this paper. The authors acknowledge funding from the Energy Foundation China, the Michelle Liem Foundation and the Grantham Foundation for the Protection of the Environment.

Samritee Kumari produced this report.

The views expressed in this report represent those of the authors and do not necessarily represent those of the host institutions or funders. The authors have no relevant financial or non-financial interests to disclose.

This paper was first published in February 2024 by the Grantham Research Institute on Climate Change and the Environment.

Suggested citation: Bian L, Dikau S, Miller H, Pierfederici R, Stern N, Ward B (2024) *China's role in accelerating the global energy transition*. London: Grantham Research Institute on Climate Change and the Environment, London School of Economics and Political Science.

Contents

Summary

The role of China in manufacturing and supply chains for the global energy transition

The transition to carbon neutrality and net zero emissions will shift the strategic priorities of countries away from securing supplies of fossil fuels, and towards the procurement of critical materials for the manufacture of clean energy technologies. If the geopolitical implications of the race for these materials are not managed well, they could slow down the pace and effectiveness of the transition. Building and strengthening the robustness and resilience of supply chains for these critical materials are vital to reduce the risk of disruption to international trade and to the transition process.

China's success in green manufacturing and clean energy technologies is primarily driven by government policies to support new industries together with the entrepreneurship of China's private sector. Its dominance in the market for clean energy technologies has involved control over supply chains of critical raw materials through domestic and overseas investments. For example, its dominance in the market for lithium-ion batteries for electric vehicles (EVs) arose from a decline in lithium prices, accompanied by government subsidies for EVs and a clear sense of strategic direction to which investors responded strongly. The growth in manufacturing of solar panels and wind turbines in China was strongly driven by demand-side policies, including feed-in tariffs, loan guarantees and tax credits, as well as public policy support for research and development (R&D).

Concerns have been expressed about the potential implications of China's dominance of the supply chains for transition critical materials. International coordination of global supply chains is important to strengthen their resilience to external shocks, whilst maintaining competition to spur innovation. Collaborations could also drive innovation, for instance to promote the use of recycled materials in the manufacture of clean energy technologies, as demonstrated by the European Union.

The role of China's trade and investment partnerships in promoting a just energy transition in the ASEAN region

The member countries of the Association of Southeast Asian Nations (ASEAN) are collectively China's largest trading partner. Strengthening cooperation between ASEAN countries and China is important to accelerate a just energy transition. The Regional Comprehensive Economic Partnership (RCEP), which was initiated by the ASEAN countries, is the world's largest free trade agreement. It aims to create a single market for intermediate goods through tariff liberalisation, and can facilitate trade in renewable energy in Asia. Member countries could strengthen coordination and communication to minimise potential trade frictions, while developing and pursuing joint policy objectives. China could improve its trade competitiveness in renewable energy products, while scaling up investments and manufacturing supply chains in ASEAN, which would accelerate the energy transition in the region.

The scaling up of China's overseas investments through the Belt and Road Initiative (BRI) could play a significant role in the development of supply chains for renewable energy technology in ASEAN countries. However, financing for renewable energy remains a major challenge because of insufficient policy and financial support from domestic government agencies and banks, including problems with the functioning of grids. The 'greening' of China's export finance and trade and supply finance could encourage domestic renewable energy companies to increase their investments in the ASEAN region.

The Just Energy Transition Partnerships (JETPs), which have been launched in Indonesia and Vietnam, could have important implications for the BRI. China and the G7 could work together to speed up the transition in ASEAN countries. China could join the Coalition of Trade Ministers for Climate, and encourage ASEAN countries to become members, to demonstrate that it recognises the importance of trade policy in promoting the transition to a zero-emissions and climate-resilient economy, and to allay concerns in some countries about China's dominance in key markets and supply chains, such as EVs and renewable energy technologies.

1. Introduction

An acceleration of climate action is imperative if the goals of the Paris Agreement are to be achieved. International trade in renewable energy can advance zero-emissions pathways. Trade in batteries, solar panels and wind turbines can incentivise technological innovation and boost production capacities, creating skilled green jobs and driving sustainable economic growth. More than 90% of countries across the globe have set domestic net zero targets, requiring a significant increase in demand for renewable energy technologies. There are tremendous opportunities for emerging markets and developing countries to improve their integration into global supply chains for clean energy technologies by leveraging intra-regional trade that boosts their manufacturing competitiveness and exports of higher-value-added products. The main steps in the development of such supply chains include the extraction of minerals; the processing of those minerals into usable materials; the manufacturing of components; their assembly into finished equipment; the installation of that equipment; its operation; and the decommissioning and reuse or recycling of some components.

As the world's largest trading nation, China holds a dominant position in global green manufacturing, particularly through the development of the so-called 'new three' clean energy technologies – that is, electric vehicles (EVs), lithium-ion batteries and solar panels. China has invested more than US$50 billion in the supply chains for solar photovoltaics (PV) and created 300,000 green manufacturing jobs since 2011. This has led to the expansion of the country's dominance in every single segment of the supply chains for solar PV, and it has more than 90% of the world's manufacturing capacity. China dominates the manufacture of polysilicon (66%), wafers (>95%), cells (78%) and modules (72%) (IRENA, 2022), and the country was responsible for nearly 40% of global growth in the generation of energy from solar PV in 2022. In spite of global trade tensions, China emerged as the largest source of imports into the EU of solar panels and wind turbines in 2021 (European Commission, 2022). China is the dominant country in the global supply chain for lithium-ion batteries, including raw materials, battery manufacturing and downstream demand (BloombergNEF, 2022a).

This policy insight aims to address two key questions:

1. What is China's role in the manufacturing and supply chains for clean energy technologies?
2. How can China support the energy transition in other countries, such as those in the ASEAN region?

2. The role of China in manufacturing and supply chains for the global energy transition

This section provides a brief overview of China's green industrialisation strategy, followed by the country's position in the supply chains for upstream and downstream manufacturing of clean energy technologies.

In the 1990s, manufacturing was concentrated in higher-income countries. China subsequently emerged as the world's manufacturing centre during the 2010s (Krugman, 2010). In 2021, China accounted for 30% of global manufacturing output (The State Council, 2022) as a result of the focus on exports in its localisation industrial strategy.

China's prominent role in clean technology manufacturing is the outcome of a long-term industrial policy that includes consistent government support, investment in highly integrated supply chains for clean energy, local innovation, and significant economies of scale. China's investments – supported by consistent policy signals and deployment targets in successive Five-Year Plans – have helped to reduce the costs of technologies, and, as a consequence, enabled China to become the leading exporter of clean energy technologies.

Industrial and trade policies have played a key role in the expansion of global and regional supply chains, such as export-led industrialisation and outward-oriented trade strategies, labour market policies, infrastructure investment and regional connectivity, which together reduce transport and communication costs, create a better investment climate and promote low trade costs.

Accelerating the clean energy transition in China and around the world requires efforts to secure an abundant global supply of critical raw materials and manufacturing capacity to produce clean energy technologies. Geographical concentrations of raw materials create risks for supply chains for the global clean energy industries. The robustness of supply chains depends on their ability to withstand shocks and maintain operations during a crisis, whereas resilience is the ability to recover and bounce back after disruption (Miroudot, 2020). The geographical concentration of supply chains can increase the risk of the global market being exposed to external shocks, such as extreme weather events in critical locations. According to the International Energy Agency (IEA), supply chain risks for EVs and solar PV are highest in the resource extraction, material production and manufacturing phases. The processing of critical minerals is concentrated in, and heavily dominated by, China (IEA, 2022).

Supply chain disruptions can trigger a reaction that further affects the operations of producers and their suppliers. Therefore, diversification of suppliers and locations of production networks across different countries is an important strategy for improving the robustness of supply chains against external shocks. Major companies from key manufacturing countries can work together to improve the security of supply chains.

A brief history of China's green industrialisation strategy

From the early 2000s to the early 2010s, China transitioned from a net importer of clean energy products to become the world's largest manufacturer and exporter, and the largest renewable energy investor. The main motivations for the expansion of renewable energy in China were mainly concerns about environmental pollution, social welfare loss and energy security, given the country's dependence on its abundant coal resources and imports of oil and gas. China introduced its Renewable Energy Law in 2006, followed by its first National Climate Change Strategy and Medium- and Long-Term Development Plan for Renewable Energy, making renewable energy a top strategic priority for its new industrial development.

In the wake of the 2008 global financial crisis, China introduced a CNY 4 trillion (approximately US$563 billion) fiscal stimulus package to promote seven strategic emerging industries, including enhancing technological and innovation capacities in renewable energy, particularly solar panels and wind turbines.

Against this background, China started to develop downstream industries to meet domestic and international demand, harnessing the entrepreneurship of China's private sector and stimulating the initial growth of the industries through policies that subsidised both domestic demand and supply (ibid.). On the supply side, the China Development Bank (CDB) was instrumental in the development of the domestic bond market and in policy design for renewable energy development (Griffith-Jones et al., 2020). Importantly, industrial policy was also designed to increase exports of renewable energy products to higher-income countries, such as those in Europe, as well as Japan and the US. Throughout the 2010s, China grew its dominance in the solar PV and wind turbine markets by producing increasingly higher-quality products and charging below-market prices. In particular, exports of solar PV became a new engine of growth in China, in part because of low market barriers and strong government policy support that led to cost reductions (Zhu et al., 2019).

Raw materials and the energy transition: China's role in mining and refining

The transition to a zero-emissions and climate-resilient economy requires the supply of transition-critical materials (TCMs) to support the deployment of clean energy technologies at a significant scale and speed (Miller et al., 2023). The production of many TCMs that are essential for the energy transition is more geographically concentrated than for fossil fuels. For example, the Democratic Republic of the Congo currently produces 70% of the world's cobalt, and just three countries – Australia, Chile and China – account for more than 90% of global lithium production (IEA, 2023a). China plays a globally leading role in the mining, refining and manufacturing of several TCMs – mostly cobalt, copper and nickel – which are vital inputs for renewable energy technologies. These technologies are also typically more materials-intensive than fossil fuels. For example, EVs require six times more materials than vehicles with internal combustion engines. The IEA estimates that there will be between a four- and six-fold increase in demand for TCMs between 2020 and 2030 (IEA, 2021).

Following the upstream operations of the extraction and mining process, the materials undergo a processing, smelting or refining process, which does not necessarily take place in the country where extraction operations are concentrated. At the end of these midstream operations, the refined materials enter the downstream production and manufacturing processes for clean energy technologies, including batteries for EVs and permanent magnets for wind turbines.

China is a leader in the midstream and downstream supply of TCMs for the manufacture of clean energy technologies, and has a comparative advantage in upstream investments through the Belt and Road Initiative. It is also the dominant player in global mineral processing, and directly (through domestic operations) or indirectly (through the BRI) controls significant parts of the extraction industry for critical minerals.

For example, China is the world's largest producer of rare earth elements (REEs),[1] which are used for wind turbines (Castillo and Purdy, 2022). It also dominates mining and refining supply chains for so-called 'battery minerals', which include aluminium, cobalt, graphite, lithium, magnesium, manganese, nickel, tantalum, tin and vanadium. China has been working towards vertically integrating the REE supply chain from extraction to processing and manufacturing components for renewable energy technologies. This illustrates the interplay of national industrial policy strategy and targeted investment by Chinese companies domestically and abroad.

[1] REEs include 17 metallic elements, four of which – dysprosium, neodymium, praseodymium and terbium – are of particular relevance to clean energy technologies.

In fact, China's dominance in TCMs through BRI investments is not as intentional as it may appear. The BRI was originally launched in 1999, as the so-called 'going out' policy, with the main objective of resource-seeking for its outward foreign direct investments in overseas markets. This created the foundation for China to improve its domestic manufacturing competitiveness, while acquiring higher-value-added technologies from higher-income countries through merger and acquisition activities. China's success in lower-cost manufacturing can also be attributed to lower environmental standards domestically and in BRI countries compared with higher-income countries.

Access to TCMs has become a national security concern and the objective of increasing competition between China and the US. For example, more than half of the supply of 25 mineral commodities to the US is highly dependent on imports from China. The global incidence of export restrictions on critical raw materials has increased more than five-fold in the last decade, with China introducing the highest number of restrictions (OECD, 2023). Recent geopolitical tensions, particularly between China and the US, foreshadow the accelerated competition to access and control TCM supply chains. The EU and US have already demonstrated their renewed ambitions for greater control over TCM supply chains with the introduction of the EU's Critical Raw Materials Act and the US's Inflation Reduction Act (European Commission, 2022; The White House, 2022). China announced that it will impose export restrictions on rare earth magnet technologies, which are used in the processing and refining of REEs for EVs and wind turbines. This highlights the pressing issue of supply vulnerability with the geographical and market concentration of production in a relatively small number of countries. It explains the international push towards a diversification of supply chains that is also regarded as potentially beneficial to long-term economic growth in lower-income countries.

Overview of mining and refining of TCMs in China

China's dominance across the supply chains for TCMs and the high level of dependence on it for these materials and their derivative products is also regarded by some as creating energy security risks (Castilio and Purdy, 2022). As illustrated in Table 2.1 for a subset of TCMs, China controls significant parts of the midstream processing industries. Particularly striking is the example of cobalt, of which China is responsible for only 1% of global extraction but has 65% of global processing capacity. Furthermore, China has control over more than half of the global processing capacity of aluminium, indium, lithium, silicon and REEs, while also dominating the extraction process for REEs.

Table 2.1 shows that China has a clear downstream competitive advantage for processing capacity, but does not necessarily dominate the upstream extraction and mining of many TCMs. However, this only represents part of the picture as China is heavily invested in the upstream production of TCMs in partner countries, principally through the BRI. While the upstream extraction and mining process does not necessarily take place in China, in many countries it is supported by Chinese companies. Alternative measurements of sources of control indicate that China may have greater control of TCM supply chains through shareholder power. For example, despite only 1% of global extraction of cobalt being domiciled in China, Chinese sources of control may account for approximately 24% of the known and active market through shareholder control (Leruth et al., 2022). As a result, the expanse and depth of Chinese control of the upstream TCM value chains may be greater than indicated by measurements of geographical location.

Table 2.1. Upstream and midstream dominance: China's role in the mining and refining of main TCMs for energy generation as a percentage of global figures, particularly for EVs, electrical storage, grid networks, and solar and wind

Material	% of reserves in China	% of extraction in China	% of processing in China	Needed for
Aluminium			58%	Biomass, concentrated solar power (CSP), EVs, grid networks, hydro, PV, wind
Cadmium	15%*		42%	PV
Cobalt	1%	1%	65%	Biomass, carbon capture and storage (CCS), electrical storage, EVs
Copper	3%	9%	42%	Biomass, CSP, electrical storage, EVs, geothermal, grid networks, hydro, nuclear, PV, wind
Graphite	16%	65%		Electrical storage, EVs
Indium			59%	PV, nuclear
Lithium	8%	15%	58%	Electrical storage, EVs
Manganese	16%	5%		CCS, electrical storage, EVs, geothermal, hydro, nuclear
Molybdenum	31%	40%		CCS, geothermal, hydro, nuclear, wind
Nickel	2%	3%	35%	Biomass, CCS, electrical storage, EVs, geothermal, hydro, nuclear, wind
REEs	34%	70%	87%	EVs, wind
Selenium	8%		41%	PV
Silicon			68%	PV
Vanadium	37%	70%		Electrical storage

Notes: *cadmium reserves are taken as the same as zinc reserves, and all reserves are deposits that are currently financially viable. Less than 20% is highlighted in green, 20–50% is highlighted in yellow, and above 50% is highlighted in red.
This list includes the nine key TCMs identified in the Miller et al. (2023) study based on expected demand-induced pressures from the net zero transition, as well as those materials required for PV and wind technologies.

Source: compiled by the authors based on data from the United States Geological Survey, IEA and Miller et al. (2023).

Table 2.2 below shows that China's dominance of the markets for clean energy technologies is built on its control over supply and value chains. For example, in the case of lithium-ion batteries for EVs, cobalt, lithium and nickel are refined in China before being turned into components such as anodes, cathodes, electrolytes and separators that are assembled as battery cells.
The dominance of China's role in supply chains for clean energy technologies is reflected within the commodity prices of TCMs, with the slump in lithium prices and expected abundance of supply attributed, in part, to the halt in subsidies for Chinese EVs (Liu and Burton, 2023).

Table 2.2. Downstream dominance: China's role in the manufacturing of clean energy technologies (in percentage of global figures)

	% manufacturing in China	Main TCMs needed
Lithium-ion battery cells	78%	Lithium, cobalt and nickel
Solar PV	59–91%*	Aluminium, cadmium, copper, indium, silicon, selenium
Wind turbines	40%	Aluminium, copper, dysprosium, neodymium, nickel

Note: *the range in estimates reflects China's role in manufacturing different components of solar PV.
Source: compiled by the authors based on Miller et al. (2023) and Ladislaw et al. (2021).

Trends in manufacturing and trade of clean energy technologies

The role of manufacturing of clean energy technologies in industrial strategy is becoming a critical consideration for policymakers, with China, the EU, the US and other countries entering a race to scale up manufacturing and deployment. Globally, manufacturing of clean energy technologies is exhibiting very high growth rates, especially for solar PV and batteries. Between 2010 and 2021, global manufacturing of solar PV increased at a compound annual growth rate of 25%. In 2022 alone, global installed manufacturing capacity[2] rose by nearly 40% compared with 2021 (IEA, 2023a). Battery manufacturing capacity is also rapidly increasing. In 2021, global battery manufacturing reached 340 gigawatt-hours (GWh), with this figure nearly doubling in 2022. This growth is mostly attributable to the increase in sales of EVs – which rose by 55% globally between 2021 and 2022 – as about 90% of these batteries are currently made for automotive applications (IEA, 2023a).

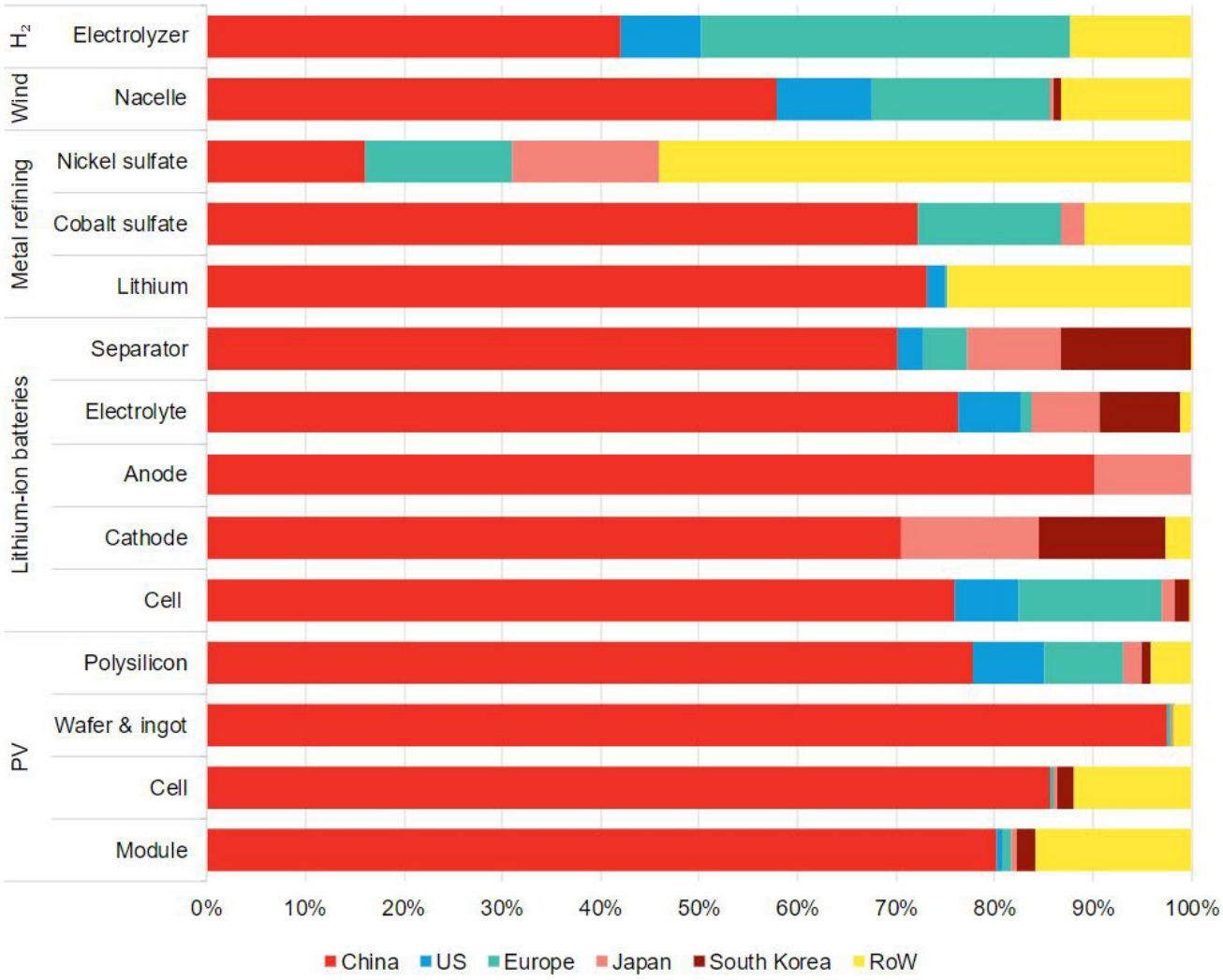
China's central position in the current manufacturing supply chain

Manufacturing operations for clean energy technologies are highly geographically concentrated. Currently, four countries and the EU account for about 80–90% of the global manufacturing capacity of five key clean energy technologies – batteries, electrolysers, heat pumps, solar PV and wind turbines. China alone accounts for 40–80% of these technologies (BloombergNEF [BNEF], 2022b) and dominates the production of all the main renewable energy technologies. This is because of a combination of long-standing manufacturing experience, lower manufacturing costs than in other countries, high fossil fuel imports, and a strategic focus on the expansion of renewables.

In 2022, three countries accounted for nearly 90% of the installed manufacturing capacity of solar PV modules. China alone hosted 80% of it, followed by Vietnam with 5% and India with 3%. China is currently the single largest producer of all three sub-components (cells, polysilicon, wafers), accounting for 85–97% of global installed capacity at each stage in the supply chain (IEA, 2023a). For batteries, China, the EU and the US together hosted more than 90% of global installed manufacturing capacity in 2022. China alone accounted for 75%, and the EU and the US held 8% and 7%, respectively. Beyond the top three, South Korea also has a sizeable share of installed manufacturing capacity at 5% of the global total (IEA, 2023a). Manufacturing of onshore wind nacelles was also highly concentrated in 2022: China accounted for more than 60% of global manufacturing capacity, followed by the EU, with just under 15%, and the US, with 10% (IEA, 2023a).

[2] 'Installed manufacturing capacity' refers to the maximum rated output of facilities for producing a given technology, as distinguished from the installed capacity of the technologies themselves once deployed. Capacity is stated on an annual basis for the final product (for example, solar PV modules) and does not speak to the capacity for producing any intermediate products and components (IEA, 2023a).

Figure 2.1. Clean energy manufacturing capacity by location



Notes: by factory location, PV, hydrogen and battery components expressed in MW, MWh, m^2 or tonnes. Nickel is the class-1 variety and lithium is in lithium carbonate equivalent. H_2 is hydrogen. Data as of October 2022, except electrolysers which refer to a 2021 and nacelle data which are for 2020.

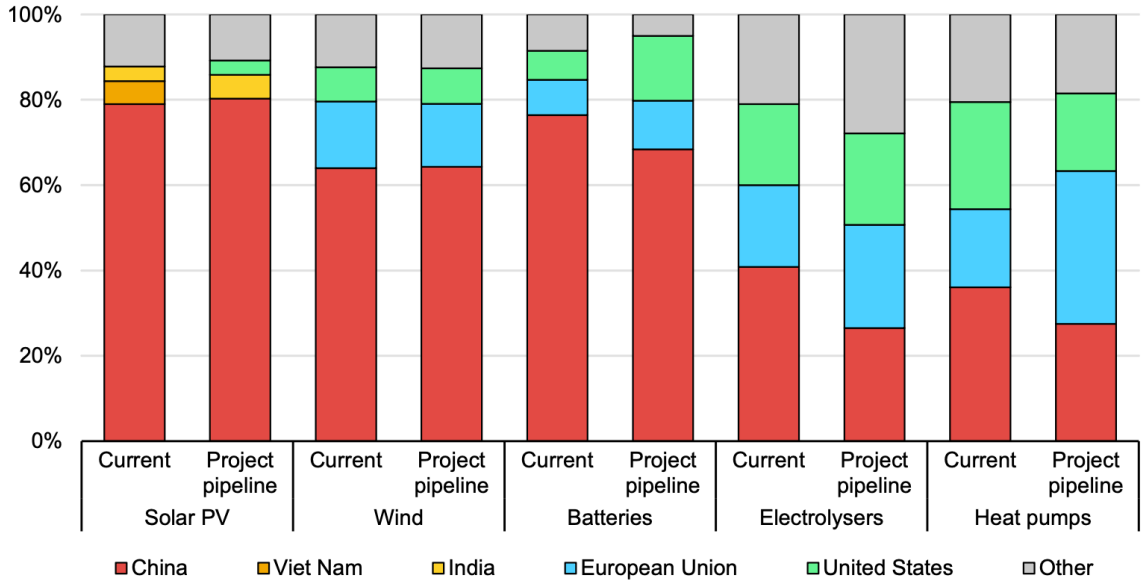
Source: BNEF (2022b).

Projected manufacturing of solar PV, wind turbines and batteries

A new pipeline of announced projects[3] for manufacturing of clean energy technologies through to 2030 has resulted from recent policy developments. This provides an indication of the direction of the industries for clean energy technologies and indicates which countries will be best positioned in the markets for these technologies in the coming years.

[3] The list of 'announced projects' has been compiled by the IEA (2023a). Many of the announced projects for solar PV and batteries have not yet started construction or reached a final investment decision. Globally, only about 25% of the announced projects for solar PV manufacturing capacity can be considered committed, with the equivalent figure for batteries being approximately 30%. As a result, the future outlook of manufacturing of clean technologies could turn out to be different from the projections above.

Figure 2.2. Current and projected geographical concentration for manufacturing operations for key clean technologies



Notes: wind refers to onshore wind nacelles in this analysis. For electrolysers, the analysis only includes projects for which location data was available. Shares are based on manufacturing capacity. 'Current' refers to installed capacity data for 2022 and Q1 2023 where available. 'Project pipeline' refers to the sum of current installed capacity and all announced manufacturing capacity additions (as of end-Q1 2023) through to 2030. 'Other' refers to the aggregate of all capacity besides that of the top three countries/regions for each technology and timeframe.
Announced projects – if all realised – will alter the global distribution of manufacturing capacity for batteries, electrolysers and heat pumps.

Source: IEA (2023a).

According to the IEA (2023a), if all announced projects for solar photovoltaics are realised, the concentration among the top three producers would remain similar to current levels, together accounting for 90%. China's share of installed capacity would remain unchanged at about 80%, while Vietnam, currently home to the second largest installed capacity, would be overtaken by India and the US.

China's shares within each of the different stages of the supply chain for solar PV would also remain stable for cells and modules, fall modestly for wafers, and increase modestly for polysilicon through to 2027. The slight changes are primarily due to project announcements in India, Thailand, the US and Vietnam.

The concentrations would remain similar for batteries, with China, the EU and the US still accounting for about 95% of capacity. China's share would decrease moderately to around two-thirds of global manufacturing capacity, while those of the US and the EU would increase to 15% and 11%, respectively. This projection is based on announced large 'gigafactory' projects located outside China.[4]

[4] The largest project planned is part of a Tesla facility in the US. At 200 GWh of annual production capacity, this project announcement is equivalent to about 13% of global battery manufacturing capacity installed today IEA (2023a).

Table 2.3. Major project announcements for solar PV and battery manufacturing operations in Q1 2023

Company	Location	Country	Production capacity	Projected completion year/year reaching maximum throughput
Batteries				
Tesla	Austin	US	200 GWh	2024/2025–2030
CATL	Yibin	China	186 GWh	Operating/>2030
CATL	Fuding	China	120 GWh	Operating/2025–2030
LGES	Wroclaw	Poland	115 GWh	Operating/2025
CATL	Debrecen	Hungary	100 GWh	2025/2028
LGES	Nanjing	China	92 GWh	Operating/>2030
CALB	Changzhou	China	90 GWh	Operating/2025–2030
Tesla	Berlin	Germany	85 GWh	2024/>2030
CATL	Luoyang	China	80 GWh	2025/2025–2030
Solar PV				
Jinko Solar	Yuhuan	China	30 GW	2024/2025
Solar grids	Zhuhai	China	30 GW	2024/2024
Tongwei	Yancheng	China	25 GW	2023/2023
Tongwei	Nantong	China	25 GW	2023/2024
Jinko Solar	Shangrao	China	24 GW	2023/2025
LONGi	Taizhou	China	20 GW	Operating/already at maximum
LONGi	Wuhu	China	20 GW	2023/2025
Trina	Yancheng Dafeng	China	20 GW	Operating/2024
Suntech	Chuzhou Fengyang	China	20 GW	2023/2024
REC Group	Jamnagar	India	20 GW	2023/2026
Solar grids	Yiwu	China	20 GW	2024/2024
Hoshine	Urumqi	China	20 GW	2023/2026
Royal	Fuyang	China	20 GW	2023/2025

Notes: 'major projects' refer to plants with stated production capacity by 2030 greater than or equal to 20 gigawatts (GW) per year for solar PV modules and 80 GWh per year for EV batteries. Any anticipated expansions beyond 2030 have not been included. The battery manufacturing facilities include all kinds of chemistries, both for mobility as well as stationary applications.

Source: IEA (2023a).

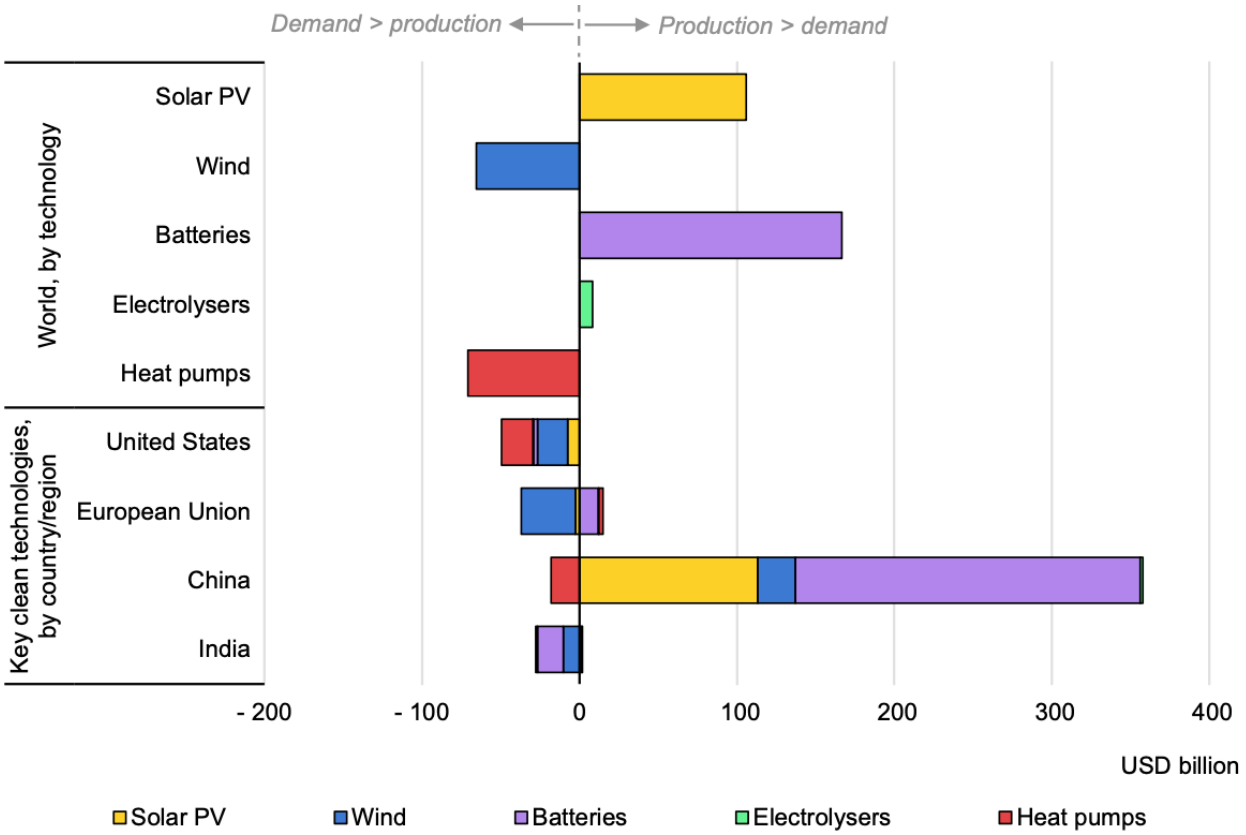
It is worth noting that the future development of capacity for battery manufacture will also be driven by factors beyond announced projects. The primary driver of additions to capacity is the market trend in EVs, as batteries account for about one-third of the price of an EV.
The countries that can make batteries for EVs will likely enjoy decades of economic and geopolitical advantages. Sales of EVs are increasing rapidly. Electric cars accounted for just 2.6% of car sales in 2019, but this is projected to reach 18% of sales in 2023 (IEA, 2023b).
In recent years, there have also been important developments in battery technology that cut costs and decrease the use of TCMs. These developments could significantly change the regional concentration of global battery manufacturing.

For wind, if all announced projects for additional capacity were to be completed, the current distribution among countries would not change significantly by 2030. The IEA (2023a) estimates that announced projects for onshore turbines would lead China to account for 55–65% of global manufacturing capacity by 2030, and up to 70–80% for offshore turbines.

Projected trade flows for solar PV, wind turbines and batteries

Announced manufacturing projects can also provide some indication of the direction and magnitude of future international trade in clean energy technologies. According to the IEA (2023a),[5] if all announced projects were to be realised, both the EU and the US would be able to fulfil all of their domestic needs for batteries by 2030.

Figure 2.3. Market value of imbalances between supply from existing and announced projects and demand in the IEA's Announced Pledges Scenario (APS)* in 2030 for key clean technologies



Notes: market imbalances are computed as the projected output from existing and announced projects (as of end-Q1 2023) less APS deployment needs for each country/region in 2030. Negative values indicate the potential value of net imports and positive values indicate the potential value of net exports. Figures are computed based on the value of the final manufactured technology (e.g. solar PV modules), with trade in intermediate components (e.g. cells) and materials (e.g. polysilicon) being outside the scope of the analysis. All domestic production is first used to meet domestic deployment needs, irrespective of existing trade patterns. *The Announced Pledges Scenario (APS) illustrates "the extent to which announced ambitions and targets can deliver the emissions reductions needed to achieve net zero emissions by 2050": see www.iea.org/reports/global-energy-and-climate-model/announced-pledges-scenario-aps
About two-thirds of the projected output from existing and announced capacity in China would be surplus to domestic requirements in the APS and would need to find export markets. Global climate ambition would need to be raised in order for them to do so.

Source: IEA (2023a).

[5] Projected estimates of future trade are calculated from imbalances between the domestic market sizes and projected output from existing and announced manufacturing supply, assuming that domestic production is first used to meet domestic demand IEA (2023a).

In the US, there will be potential net import needs for heat pumps, solar PV and wind, while the domestic market imbalance in the EU would reach US$20 billion in imports for wind and solar PV. However, the Green Deal Industrial Plan and Net Zero Industry Act can be expected to change these projections.

For China, about two-thirds of the projected output from existing and announced capacity of key clean energy technologies would be surplus to domestic requirements and would need to find export markets over the next seven years. The combined output of existing and announced projects is estimated to reach nearly 860 GW for solar PV and about 70 GW for wind by 2030, compared with deployment needs of 108 GW for solar PV and 41 GW for wind per year. For batteries, while existing manufacturing output would not be sufficient to satisfy domestic demand in China, the pipeline of announced projects would lead to production that is about four times the volume of its domestic demand by 2030. For solar PV and batteries, global climate ambition would need to be raised in order for China to find big enough export markets.

Box 2.1. Building robust and resilient supply chains for clean technologies

The race in manufacturing of clean energy technologies will redefine global energy security and shift the focus from the supply of fossil fuels to the supply and concentration of the minerals, materials and manufacturing capacity needed to deliver these technologies.

Concentration at any level along a supply chain can create vulnerabilities, with the potential to affect the entire supply chain for a given technology. As seen in this section of the report, for key clean energy technologies such as solar PV and batteries, high levels of geographical concentration can occur at each of the major steps in the supply chain, from minerals mining to downstream manufacturing. Concentration makes a supply chain vulnerable to individual countries' policy choices, natural hazards or company decisions.

To address the risks posed by geographical concentrations in supply chains, countries can adopt different tools, including developing industrial strategies that leverage their competitive advantages, pursuing diversification strategies for origins of supply, and types of technologies and materials employed.

To build supply chains that are secure, and limit vulnerabilities associated with geographical concentrations and import dependencies, countries should foster international coordination in the global supply chains for clean energy technologies (see below). The use of recycled materials will also be crucial to ensure resilience of supply chains, and countries are already moving forward in this direction. The EU, for example, will require batteries for EVs to contain at least 16% recycled cobalt and 6% recycled lithium and nickel by 2030 (EU, 2023). China is catching up quickly too. A unit of the manufacturing firm Contemporary Amperex Technology (CATL) is investing up to CNY 32 billion (US$5.04 billion) to open a recycling facility as early as 2027 (Reuters, 2021).

Policy implications

China's dominance in the global manufacturing industry and supply chains for clean energy technologies has resulted from coordinated policy and investment, which has helped to reduce costs and increase supplies globally for key technologies, such as lithium-ion batteries and solar PV. However, this dominance is also a source of concern for the transition to a zero-emissions and climate-resilient global economy, as well as the economic competitiveness of other nations. Not only are production and supply vulnerable to policy decisions by China, such as trade restrictions, but geographical concentrations increase the risk of disruption by localised extreme events and natural disasters. These risks are increasing as a result of the growing impact of climate change, particularly more frequent and intense extreme weather events. China and other countries around the world are exposed to the consequences of these vulnerabilities.

As a result, all countries, including China, would benefit from supply chains for clean energy technologies that are more robust and resilient.

The IEA initiated its Critical Minerals Policy Tracker in November 2022, and it now covers more than 35 countries and 450 policies. It shows that countries are using a range of policy options to limit the risk of disruption to supply chains. These policies are often accompanied by national strategic plans that designate particular minerals as 'critical' or 'strategic'. Some governments are also responding through systems for stockpiling critical minerals, or coordination with other countries to promote the robustness and resilience of supply chains. Others are investing public funding to expand domestic sources, through state-owned enterprises (SOEs) for instance, or procurement programmes that apply criteria to guarantee buyers for materials.

International cooperation will be crucial, and a multilateral approach would be better than a bilateral one. International coordination across supply chains should aim to increase resilience and address the risks posed to the different segments of the chain that could create delays and disruption. This requires collaboration on the diversification of the origin of supplies among several trade partners to increase resilience to supply chain shocks. It also involves diversifying technology and material needs, through technology or material substitution, to increase security of supply, especially when technologies and materials are geographically concentrated. International collaboration will also be helpful to increase investments in innovations that reduce the use of critical minerals and promote recycling and reuse.

Coordination of international value chains should be built in a way that enables countries to specialise in segments where they have a comparative advantage. This implies identifying and building strategic partnerships, between advanced and developing countries, within the G20 and beyond. G7 members have already recognised the importance of building resilient, secure and sustainable supply chains to accelerate the clean energy transition and reduce vulnerabilities associated with undue dependencies (G7, 2023).

3. The role of China's trade and investment partnerships in accelerating a just energy transition in the ASEAN region

Given China's crucial role in the supply chains for clean energy technologies, there is a clear opportunity for it to strengthen its support through trade and investment for zero-emissions and climate-resilient economic development in other countries. This section explores the potential for China's trade and investment to accelerate a just energy transition in member countries of the Association of Southeast Asian Nations.

Some G7 countries have launched bilateral development initiatives that aim to reduce the economic dependence of emerging markets and developing countries on China. For example, the Partnership for Resilient and Inclusive Supply-Chain Enhancement was announced in 2023 by G7 finance ministers to address vulnerabilities resulting from the high geographical concentration of supply chains. Following the launch of the Build Back Better World initiative by the US, the creation of the Indo-Pacific Economic Framework for Prosperity (IPEF) supports sustainable and resilient economic growth in ASEAN countries, including through strengthening the resilience of regional supply chains in the 14 IPEF member countries, comprising Australia, Brunei, Fiji, India, Indonesia, Japan, Republic of Korea, Malaysia, New Zealand, Philippines, Singapore, Thailand, Vietnam and the US (Asia Society Policy Institute, 2023).

Adopting a country-driven approach will enable major international development partners to maximise the development synergies in ASEAN countries through their bilateral and multilateral initiatives. In particular, improved G7–G20 collaborations could be significant in addressing the interrelated global challenges of climate change and supply chain disruption. Investment opportunities can only be realised through collective efforts to close the substantial financing gaps required for the net zero transition: for example, by supporting ASEAN countries to build up local manufacturing capacities to meet the rising demand for energy.

In focusing on the challenges and opportunities for China in scaling up supply chains for clean energy technology to promote cooperation with ASEAN countries, this section examines:

1. Regional trade integration through the Regional Comprehensive Economic Partnership
2. Overseas investments through the Belt and Road Initiative
3. Just Energy Transition Partnerships.

Regional trade integration and the role of China

In general, Asian countries have performed better than other emerging markets and developing countries in catching up with frontier value-added manufacturing. This has been achieved through higher inflows of foreign direct investment, primarily driven by increased investments in the infrastructure for information and communications technologies (ICT), enhanced skills, R&D, and a conducive business climate (United Nations Conference on Trade and Development [UNCTAD], 2023). According to the readiness index produced by the UNCTAD, which combines indicators for ICT, skills, R&D, industrial capacity and finance to support countries to use, adopt and adapt frontier technologies, additional efforts are required by ASEAN countries to attract foreign direct investment in clean energy technologies. For instance, Thailand is the only ASEAN country ranked in the top 50 (49) in the readiness index, followed by the Philippines in 54th place, Vietnam in 62nd place, and Indonesia in 85th place. Changes in policy have been identified as the most important driver of capturing clean energy technological innovation (for example, through the development of industrial clusters, smart specialisation initiatives and demonstration projects).

Overview of the participation of ASEAN countries in regional manufacturing value chains

The role of ASEAN countries in global value chains is mostly driven by backward participation ('import to export'), which is often described as countries importing foreign inputs to produce the goods and services they export, or foreign value-added in a country's exports (OECD, 2022). China is a major supplier of industrial inputs to exports by ASEAN countries (Baldwin, 2022). Although backward integration of global value chains can create jobs, major international trade benefits derived in ASEAN countries are mainly concentrated in the primary sector and lower-skilled services sector where there is lower productivity growth. Furthermore, the rate of upgrading value chains in ASEAN countries has been uneven. For example, activities related to global value chains in Laos and Myanmar have been concentrated in primary sectors, while others have moved into manufacturing and services at different paces, partly due to variation in skills, technological capabilities, infrastructure connectivity and enabling environments.

The trade between ASEAN countries and China, Japan and the Republic of Korea is three times larger than trade between ASEAN countries. China has been the largest trading partner for the ASEAN region since 2009, and bilateral trade rose to US$975.3 billion in 2022 from US$641.5 billion in 2019 (Mission of the People's Republic of China to ASEAN, 2023). The value of China's exports to the US and EU dropped by 15% and 5%, respectively, in the first half of 2023, but exports to ASEAN countries grew by 8% compared with the same period in 2022. Further, the ASEAN region was ranked second (after China) among Global South destinations for foreign direct investment inflows, accounting for US$174 billion in 2021 (UNCTAD, 2022). Inflows of foreign direct investment to ASEAN countries from China reached US$13.6 billion in 2021 compared with US$7 billion in 2020, and were primarily concentrated in the manufacturing industry. Following the establishment of the ASEAN Economic Community in 2015, Special Economic Zones, including Export Processing Zones (EPZs) and industrial parks, have become increasingly important as policy tools to attract foreign investors who seek to diversify their supply chains. China's trade relationship with ASEAN implies that a 1% positive shock in China's output would generate an increase of 6.3% in the ASEAN region's output in 2020, compared with a rise of 4.9% in 2010 (Asian Development Bank [ADB], 2023).

The role of the Regional Comprehensive Economic Partnership

The RCEP is widely regarded as a potential framework to shape investment patterns, while promoting regional economic integration in Asia, by raising productivity growth due to reduced trade friction. Led by the ASEAN countries, the RCEP agreement is the world's largest free trade agreement. The RCEP came into force on 1 January 2022 and is the first multilateral trade agreement involving China. Its aim is to improve market access with lower tariffs in 15 member countries – that is, 10 ASEAN countries, together with China, Japan, South Korea, Australia and New Zealand – which account for 30% of global gross domestic product, or US$26.2 trillion, and more than a quarter of global trade. A report by the Asian Development Bank suggests that intra-regional trade under the RCEP will increase by 12% by 2035, while other studies show that income levels will rise by 0.6%, with 2.8 million more jobs created by 2030 (Park et al., 2021).

The major advantage of the RCEP is the creation of a single market for the intermediate goods that will be incorporated into final products, through the harmonisation of rules of origin for exports of goods. This can substantially improve trade relationships between member countries, and the cohesiveness of trade rules, by preventing the consequences of the 'Asian noodle bowl' associated with dozens of overlapping free trade agreements suffered by exporters (The Economist, 2023). In 2022, China's trade volumes with RCEP member countries increased by 7.5%, of which imports and exports with ASEAN accounted for about half. In particular, China's trade in intermediate products (such as electronic and mechanical components, including batteries, metal ore and vehicles) represented 67% of China's total trade volume with ASEAN. This reflects increasing cooperation within supply chains (SCIO, 2023).

Many ASEAN countries regard the RCEP as an opportunity to foster the clean energy transition, with the opportunity to benefit from green industrial exchanges with China. The RCEP could provide improved access to renewable energy technologies in ASEAN countries, while enhancing China's green export competitiveness.

Indonesia is the key initiator of engagements within the RCEP, and the country has abundant raw materials and a cost-effective supply of labour, making it well positioned to upgrade its value chains by attracting foreign direct investment from Chinese investors. Most recently, in 2023, the Philippines ratified the RCEP, and the country has indicated that it intends to seize this strategic opportunity to promote the transition towards more affordable renewable energy. Nonetheless, structural reform in ASEAN countries would be required in order to fully realise the economic benefits of these new trade opportunities (Thangavelu et al., 2021).

The RCEP can boost trade in lithium-ion batteries, solar panels and wind turbines in ASEAN countries through tariff liberalisation. It aims to eliminate tariffs for more than 90% of tradable goods within 20 years. For solar energy products, most of the RCEP countries already have a liberalised or zero tariff rate, meaning that the tariff barrier is deducted from the trade costs for PV cells and modules/panels. Countries including Indonesia, Laos and Myanmar committed to eliminating tariffs in year one of the RCEP's implementation. Although Indonesia and Thailand have the highest tariff rate of 10% for wind turbine generators, both countries agreed to fully liberalise this in year one, while Cambodia, Malaysia, Vietnam and others have duty-free access or very low tariff rates of about 1%. In addition, a 6% tariff on some lithium-ion batteries is due to be scrapped by 2038.

The RCEP can support the growth of small- and medium-size enterprises (SMEs) in regional value chains. For example, Vietnam could benefit the most from the RCEP, given that SMEs account for 98% of all firms in the country (Vietnam Briefing, 2022). SMEs provide the most job opportunities, but they tend to face disproportionate barriers in international and regional trade, such as complex and inefficient customs administrations and high logistics costs. The RCEP can improve customs clearance efficiency by reducing the time of customs clearance to within 48 hours for imported goods. However, the administration of rules of origin can be a significant cost for SMEs, which is often reported as a non-tariff barrier (ADB, 2022).

The role of international trade in supporting climate and development, as well as job creation and growth, has been hindered by the finance gap in global trade, which rose to about US$2.5 trillion in 2022 (Beck et al., 2023). Supply chains are deep and complex global networks, with the supplier at the top of the chain (tier-one supplier) relying on several lower tiers to deliver a finished good to the end buyer. The major challenge to integrating regional value content is the lack of credit line support for SMEs, which are involved lower down the chains and provide 90% of jobs in ASEAN. The multilateral development banks (MDBs) have tried to fill this gap with trade and supply finance, using the credit standing and mutual dependence of supplier inputs of a company at the top of a supply chain to enable financing for companies lower down the chain. Simply put, the MDBs provide guarantees and loans to crowd in private sector participation, backed by strong credit ratings.

Large companies at the top of supply chains often have little or no information about the SMEs further down the chain, which creates obstacles in calculating Scope 3 emissions of greenhouse gases, and makes it harder to integrate environmental, social and corporate governance (ESG) considerations into supply chains. This is particularly relevant to the development of supply chains in ASEAN countries by Chinese state-owned enterprises, which need to have a better understanding of the sustainability of the SMEs involved in the downstream of supply chains. For example, the International Financial Reporting Standard can support climate-related financial reporting to address the complex challenge of tracking Scope 3 emissions.

Overseas investments and the role of China's Belt and Road Initiative

The Third Belt and Road Forum in 2023 revealed that, since the launch of the BRI in 2013, China's total investments through loans have reached more than US$687 billion. BRI engagement in the form of construction contracts and investments has been dominated by infrastructure investments in the energy and transport sectors. BRI finance and investments rose until 2015, after which they declined until 2020, to US$47 billion, before increasing to US$68.7 billion in 2021, and dropping slightly to US$67.8 billion in 2022. In 2023, the fastest growth for BRI sectoral investments was recorded in agriculture, followed by TCMs and mining (131%), compared with the first half of 2022 (Nedopil, 2023a). Lithium and copper mining and processing are the emerging priorities for BRI investors in Africa and Latin America.

Following China's commitment to end financing for construction of new coal-fired power stations in BRI countries in 2021, Chinese overseas BRI investments in renewable energy have been on the rise (Nedopil, 2023b). For example, China's largest overseas supply chain for solar PV has been established in Malaysia by Jinko Solar, the world's third biggest solar energy company. Many leading Chinese solar manufacturers (for example, JA Solar and Longi) have been scaling up their investments in Vietnam. Chinese manufacturers in energy storage are also increasing their investments in Vietnam (Guarascio and Nguyen, 2023).

However, China's investments in renewable energy are still far lower overseas than domestically. Between 2013 and 2023, total investment in the energy sector accounted for US$12.3 billion, of which US$990 million was in renewable energy including hydropower, solar and wind. Of total energy investments through the BRI between 2010 and 2019, only 22% were in renewable energy. By contrast, renewables represented 77% of domestic investments in energy by China over that period (Larsen and Oehler, 2022).

In BRI countries, Chinese private companies have played a leading role in financing renewables (Zhou et al., 2018; Gallagher, 2019). For example, private companies accounted for only 8% of China's overseas BRI energy investments in 2018, but they provided financing for about 65% of renewable power generation projects other than hydro (Larsen and Oehler, 2022). This implies that major state-owned BRI financiers[6] have primarily provided energy financing for fossil fuel investments. Between 2000 and 2022, state-owned policy banks the CDB and Export-Import Bank of China (CHEXIM) provided 73% of lending for power generation by coal, oil and gas in BRI countries, according to research by Boston University (Springer et al., 2023). Given that China did not issue any new energy sector loans to BRI countries in 2021 and 2022, a shift towards renewable energy investments has not yet been delivered, despite China's 2021 pledge to step up its green BRI commitment (ibid.).

Financing is the major barrier to scaling up renewable energy investments in BRI countries. Firstly, the financing costs of renewable projects in these countries are higher than in China. This is due in part to the complex administrative procedures that delay the subsidy payments offered by China's Renewable Energy Investment Fund to developers that scale up solar and wind power projects overseas (Ma, 2020).

Secondly, China's financial system provides preferential treatment to state-owned enterprises, which can limit the ability of renewable energy companies in the private sector to access project financing from domestic financial institutions. State-owned enterprises are willing to accept unattractive risk-return profiles, in part because they can access low interest rates for project financing from Chinese commercial banks and policy banks (Bian, 2023).

[6] These include policy banks (such as the Agricultural Development Bank of China, CDB and CHEXIM), and the 'big four' state-owned banks (that is, the Agricultural Bank of China, Bank of China, China Construction Bank, and Industrial and Commercial Bank of China).

Insufficient institutional and knowledge capacities are another major challenge. Chinese project developers are less experienced in the bidding process for renewable energy projects in BRI countries, where auction schemes are popular (Ma, 2020). In addition, Chinese companies have limited experience of cooperating with international financial institutions in the development of financing for renewable energy projects in BRI countries – for instance, on risk-sharing modalities to improve economic viability.

Lastly, Chinese export credit agencies (ECAs), which play an important role in providing bilateral export finance to strengthen China's economic cooperation with BRI countries, have not provided adequate financial incentives to encourage trade in renewable energy with BRI countries. For example, the export financing activities of the CHEXIM mainly provide targeted support to state-owned enterprises in the fossil fuel sector. The China Export & Credit Insurance Corporation (SINOSURE), another state-owned ECA, is less experienced in assessing country risks in BRI countries. Consequently, innovative financial instruments and modalities, and products such as guarantees, might not be offered by China's ECAs to improve the financial viability of renewable energy projects.

It should be noted that the ECAs in G20 countries, particularly Japan, South Korea and Canada, were among the largest major export financiers of fossil fuel investments in emerging markets and developing countries between 2006 and 2020, with the primary destination in the Asia-Pacific region (Peterson and Downie, 2023). In 2022, led by the Japan Bank of International Cooperation (JBIC), Asian export and import banks, including CHEXIM, issued a joint statement pledging to strengthen collective efforts to tackle climate change (JBIC, 2022). In June 2023, CHEXIM signed a series of cooperation agreements with the Asian Development Bank to jointly develop co-financing opportunities for climate projects in BRI countries (ADB, 2023).

Implications of Just Energy Transition Partnerships for China's BRI

A brief overview of the JETPs

China is committed to supporting lower-income countries, and the creation of JETPs poses both a challenge and an opportunity for China. In the ASEAN region, Indonesia and Vietnam launched JETPs in 2022, while the Philippines has expressed its intention to also create a JETP (Cordero, 2023). China is Indonesia's largest trading partner and Vietnam's fourth largest. JETPs present opportunities for companies in both countries to improve their capacity and become part of the manufacturing value chain for clean energy goods.

The JETPs for Indonesia and Vietnam each aim to achieve net zero emissions by 2050, by accelerating the early retirement of coal-fired power plants and boosting renewable energy investments. Indonesia and the leaders of International Partners Group (IPG), co-led by Japan and the US, and including Canada, Denmark, the EU, France, Germany, Italy, Norway and the UK, announced in February 2023 a plan to mobilise US$20 billion during the next three to five years to accelerate a just energy transition in Indonesia's power sector. This includes US$10 billion of public finance that will be mobilised by the IPG members, and at least US$10 billion of private finance that will be mobilised and facilitated by the Glasgow Financial Alliance for Net Zero Working Group. The Vietnam JETP builds on the UK-launched G7 Partnership for Global Infrastructure and Investment, and, together with the same IPG members for Indonesia's JETP, aims to mobilise US$15.5 billion over the next three to five years.

The JETPs include a target of peaking power sector emissions by 2030, which brings forward the projected peak dates set by their respective governments by seven years in Indonesia and five years in Vietnam. In Indonesia, solar accounts for less than one percentage point of the 12% of power that is currently generated by renewables, primarily from geothermal and hydropower sources.

Although Indonesia has local content requirements for the renewable energy industry, the domestic solar industry still lags behind with an annual production capacity of only 1.6 GW in 2022, compared with the capacity of 300 GW that is estimated to be needed to achieve net zero power sector emissions by 2030 (Roesad, 2023). In Vietnam, total electricity capacity stood at 69 GW in 2020, with renewable energy accounting for 17 GW, or 25.3%, of the total power capacity.

The country aims to further unleash the potential of solar and offshore wind power (US International Trade Administration, 2021). With international support, Indonesia plans to generate at least 34% and Vietnam at least 47% of electricity from renewables by 2030. Comprehensive investment plans for each JETP consist of an investment plan and implementation roadmap, alongside a policy plan for on-grid power, off-grid power and captive power in industry use.

The role of JETPs in country-specific contexts: main barriers to progress

There are country-specific opportunities and barriers relating to BRI energy investments in Indonesia and Vietnam. New coal-fired power plants and coal mining operations were announced in 2022 in Indonesia, with Chinese state-owned enterprises due to be involved in the development of power plants in industrial parks (Lim and Seng, 2022). For example, China Energy Engineering Corporation won the bid to build a captive coal-fired power plant in an industrial park in Obi Island, along with a coal mining project in Central Kalimantan, supported by Power Construction Cooperation of China, which aims to produce 30 million tonnes of coal in total (Nedopil, 2023a). However, Indonesia overestimated how much its demand for power would rise, which means there has been investment, particularly from China, in coal-fired power plants that are currently unused.

Many negative consequences of coal-fired power plants in Indonesia and Vietnam have been documented, particularly their impacts on human and ecosystem health, rural livelihoods and food security. For example, in Morowali Industrial Park in Indonesia, 34,000 workers have suffered from acute respiratory infections (Indonesia BusinessPost, 2022). Also, coal-fired power plants face legal risks, with climate litigation cases already filed in China, Indonesia, the Philippines, South Africa and Thailand against governments and companies that continued to burn coal for failing to protect human rights, health and wellbeing against threats from climate change and air pollution (Setzer and Higham, 2023). The 26th session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP26), held in Glasgow in 2021, called upon countries to "accelerate the development, deployment and dissemination of technologies, and the adoption of policies to transition towards low-emission energy systems, including by rapidly scaling up the deployment of clean power generation and energy efficiency measures, including accelerating efforts towards the phasedown of unabated coal power and phase-out of inefficient fossil fuel subsidies, while providing targeted support to the poorest and most vulnerable, in line with national circumstances and recognising the need for support towards a just transition". Hence, there is a widespread understanding of the urgent need to accelerate the just transition away from coal-fired power plants.

Policy and regulatory uncertainty remain the biggest barriers to the transition to low-carbon power. Indonesia enacted the Presidential Regulation on the Acceleration of Renewable Energy Development for Electricity Generation in 2022. This mandates new tariff and procurement mechanisms by the state-owned electricity provider Perusahaan Listrik Negara (PLN) to purchase renewable electricity from independent power producers. It provides ceiling prices for electricity that are higher than the average national generation costs, meaning that PLN creates incentives for independent power producers to replace diesel-powered electricity generators with solar PV. However, PLN already has too many coal power purchasing contracts, which affects its ability to offer attractive prices for independent power producers to source renewables. The effectiveness of the Presidential Regulation remains unclear, in part because the construction of coal-fired power plants registered in PLN's 2021–2030 Business Plan (that is, prior to the announcement of the Presidential Regulation) is still permitted.

Coal mining for export is an important source of government revenue in Indonesia, and so remains an important obstacle to implementation of the JETP. In 2022, of 687 million tonnes of coal produced in Indonesia, 494 million tonnes were exported, primarily to China, which has been Indonesia's most important export destination since 2011 (Reuters, 2023; MEMR, 2022). China's zero-coal import tariffs were extended until the end of 2023 to strengthen domestic energy security and to minimise disruptions to industrial supply chains from climate-related extreme weather events. This indicates that a change in China's fiscal policy to end zero-coal import tariffs would accelerate its domestic energy transition and send a strong signal to Indonesia that it should shift its strategic focus away from coal mining and towards responsible mining for TCMs.

Political risks are delaying the implementation of the JETP in Vietnam by creating significant uncertainty for international investors, including BRI financiers. Energy and climate policies led to a solar power boom in 2019, which caused significant economic burdens, particularly for the state-owned grid operator Vietnam Electricity (Konig, 2023). As a result, the implementation of energy policies by the Ministry of Industry and Trade is currently under investigation, which may impede efforts to advance energy sector reform in Vietnam. The JETP agreement for Vietnam, unlike Indonesia's, includes a clause to ensure the participation of civil society and media to develop a broad social consensus on achieving a just and equitable transition. However, the arrest of a female advocate for renewable energy in 2022 has created fear within civil society and damaged Vietnam's international reputation and credibility on this front.

Box 3.1. Case study: China's potential contributions to the development of the 'blue economy' in Vietnam and Indonesia through offshore renewables

The development of the blue economy – economic activities associated with the oceans and seas that can boost sustainable economic growth, improve livelihoods and jobs, and ocean ecosystem health – is a priority in Vietnam and Indonesia. China could play a major role, given its experience in this area: it has produced nearly half (44%) of the world's offshore wind turbines (Buljan, 2023), and the world's largest floating solar farm (320 MW) is located in Dezhou, Shandong province.

While Vietnam did not generate any power from offshore wind in 2020 (Donaldson, 2023), the country has rapidly increased its solar energy capacity since the COVID-19 pandemic. Important policies include offering attractive feed-in tariffs, increasing market competition through power purchase agreements to challenge the state monopoly, implementing fiscal stimulus packages to encourage investment, and promoting international collaboration (Rapid Transition Alliance, 2023).

China has increased investment in the supply chain for solar PV in Vietnam, and Longi has supplied PV modules to the first large-scale project for floating solar panels in the country (Longi, 2021). This is the first project in the country that has not required a government guarantee, which is designed as an important policy tool in traditional project financing that is used to improved bankability of infrastructure projects, with the risks borne by the government providing the guarantee. Although it can improve investor confidence, the use of government guarantees is linked to several risks, including reduced incentive for the private sector to adequately conduct due diligence in the project planning stage, which may cause project delays and pose a fiscal risk to government (World Bank, 2020). Instead, the Asian Development Bank has provided an innovative financing mechanism for this project with blended concessional financing to incentivise private sector participation, which can potentially reduce public fiscal burden. Chinese companies could seize these solar and wind investment opportunities created by the JETP, with the ADB providing due diligence checks on projects.

In Indonesia, the joint development of offshore wind projects could benefit from China's competitive advantage in manufacturing growth, and innovative offshore wind technologies developed by countries such as the UK and the US (for example, the latter's noise attenuation technology [Kershaw, 2021]). This could decrease the costs of generating offshore wind energy and reduce the risks to ecosystems and wildlife caused by the blades of offshore wind turbines, which can cause underwater noise pollution, affecting marine life, as well as negative effects on birds, other wildlife and commercial fisheries.

Chinese BRI investments, with third-party cooperation, in offshore wind farms can potentially improve energy security, food security and rural livelihoods in these countries. There is growing evidence that the operational phase of offshore wind farms can potentially lead to changes in local habitat characteristics, which could increase food availability through changes in the trophic interactions between fish and crustacean species (EU, 2018). However, more research is needed to deepen the understanding of the risks and benefits of offshore wind farms on marine ecosystems.

China's experience in applying a range of industrial policies to develop and upgrade domestic production capabilities could help boost knowledge sharing with ASEAN countries – for example, fostering a blue economy through offshore renewable energy development. China has successfully promoted the creation of new solar and wind energy companies through a combination of state ownership, the use of subsidised credit from state-owned banks, public procurement and public investments (Chang and Zach, 2019). After the build-up of domestic production capabilities, China's strategy turned towards the development of R&D capacity, the expansion of domestic linkages and vertical diversification. One important strategy has been the targeted use of foreign direct investment in EPZs to help domestic producers engage in international markets. For example, companies in EPZs can expand the number of domestic firms within their supply chains. This can enable quick integration into international supply chains, while increasing learning and organisational capability, and upskilling technical staff.

Policy implications

Leveraging the RCEP to scale up sustainable trade and investment

The interim Secretariat of the Regional Comprehensive Economic Partnership is expected to be established as a special unit within the ASEAN Secretariat in Jakarta, Indonesia, to help strengthen regional supply chains and economic integration (Thai PBS, 2023). The RCEP Ministerial and Joint Committee could play a central role in implementing the JETP in Indonesia and across the ASEAN region. The RCEP could scale up trade and foreign direct investment by reducing the costs of coordination between member countries. The RCEP Secretariat can provide technical support to bolster stakeholder engagement and capacity building, while addressing potential trade friction, drawing on the example of the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP). The CPTPP has created a Commission as its decision-making body, supported by ministerial conferences and technical groups, to consider policy issues relating to climate change and trade (ASEAN, 2022).

Member countries of the RCEP could also set joint objectives for industrial policy to promote zero-emissions and climate-resilient development and growth. The RCEP recognises the importance of economic, environmental and social as the three pillars of sustainable development provisions. Currently, however, its primary focus is on establishing a Committee on Sustainable Growth that supports the growth of SMEs, economic cooperation and emerging issues (MOFCOM, 2020). In contrast to the CPTPP, it does not explicitly include other key elements of sustainable development, such as measures to protect human, animal or plant life, or health, labour rights and standards, or human rights, or to promote gender equality (Armstrong and Drysdale, 2022; Malingrey and Duval, 2022; Taylor-Strauss H, 2021). Nor does the RCEP explicitly address the challenges of climate change and biodiversity loss.

Nevertheless, the RCEP could boost renewable energy investments by facilitating investment that can specifically address trade- and investment-related environmental challenges and by enacting environmental and labour protection laws, while also promoting corporate social responsibility. The RCEP could draw on the experience of other international agreements, such as the EU's free trade agreements (FTAs) with Japan, through which the two jurisdictions have reaffirmed their efforts to achieve climate commitments and stressed the importance of trade and sustainable development (ibid.). The EU's FTAs with Singapore and Vietnam include a provisional chapter to reduce the costs of doing business by removing non-tariff barriers, such as inconsistent standards, regulations, testing requirements, increased compliance and labelling standards. If the RCEP acted similarly, regional trade in renewable energy technologies could be better facilitated across RCEP countries through reduced trade costs.

A changing role for trade finance in a just energy transition

Stronger financial support from China's ECAs could help to close the investment gaps that are holding back the transition to a zero-emissions and climate-resilient economy. Closer collaboration through financing modalities, co-financing and guarantees could be implemented by the ECAs to mobilise public and private capital. They could also consider temporary suspensions of debt to strengthen the resilience of supply chains in ASEAN countries. Following the Summit for a New Global Financing Pact in Paris in June 2023, the ECAs of France, the UK and the US have been taking action to implement debt pause clauses for some climate-vulnerable countries that are suffering from the devastating impacts of climate-related disasters. If CHEXIM and SINOSURE offered similar policies, ASEAN countries would recover faster from disasters and be able to minimise the potential loss and damage across supply networks, which would also reduce risks for China's domestic economic growth.

By allowing a scaling up of supply chains for renewable energy in ASEAN countries, Chinese regulators can play an enabling role in supporting the overseas expansion of China's domestic renewable energy companies. While the Ministry of Commerce and the National Development and Reform Commission are responsible for approving overseas BRI projects, the State Council, the State-owned Assets Supervision and Administration Commission of the State Council, and China Investment Corporation have mandates for, and oversight of, the majority of financial flows. A whole-of-government approach could enable a coordination mechanism to be set up to jointly discuss policy solutions and offer economic incentives for SOEs and SMEs to scale up renewable energy investments in BRI countries. The People's Bank of China could provide credit support to increase the overseas participation of renewable energy SMEs among its measures to improve the security and resilience of supply chains (State Council, 2021).

China's policy banks and commercial banks could also offer affordable finance to support SMEs in ASEAN countries that integrate into supply chains for renewable energy technology, as are being established by Chinese investors.

Strengthening international collaboration through the MDBs and other institutions

There is an opportunity to promote a just transition through the development of high-quality BRI projects. UN agencies have already been playing a critical role in 'greening' Chinese overseas investments in BRI countries, either directly (through funding support and capacity building) or indirectly (through changes in policies and safeguards to influence China's investment decisions) (Gong and Lewis, 2023). The multilateral development banks have also been important in providing technical support and policy advice, and mobilising resources at scale to improve the affordability and equitability of the energy transition in many developing countries. China's public and private investments through the MDBs, such as the Asian Infrastructure Investment Bank, can significantly improve the quality of BRI projects, which would have multiple benefits for BRI countries. Rigorous environmental and social policy frameworks, debt sustainability frameworks, and institutional and policy support by the MDBs can mitigate climate- and nature-related risks potentially faced by Chinese investors, improving their risk-adjusted return profiles. For example, strategic environmental and social assessments or safeguard policies can avoid, minimise, mitigate and compensate for potential adverse project impacts on the environment and communities.

Likewise, Chinese companies can use collaborations with the MDBs as learning opportunities to improve their capacity for developing BRI projects that are in line with ESG standards and that foster a just transition.

Participation in the JETPs can encourage BRI financiers to revise their corporate policies to stop financing new captive coal-fired power plants and avoid investing in other coal-related stranded assets. Chinese investments can create social co-benefits to support a just power transition in ASEAN countries. For example, Chinese investors, supported by the JETP secretariat, can invest in the research and development and adoption of energy storage and hydrogen technologies, rather than continuing with existing coal contracts, which also provides opportunities to create green jobs and improve productivity growth in the ASEAN region. In return, ASEAN governments could offer incentives, such as tax breaks and subsidies, to attract Chinese investors.

The development of carbon markets in the JETP countries could also be a potential source of revenue to support the early retirement of coal-fired power plants. For example, the Coal to Clean Credit Initiative has the potential to incentivise a just transition away from coal, by channelling revenues generated from carbon credits to support workers and communities affected by the closure of coal-fired power plants (Rockefeller Foundation, 2023).

Innovative financing structures developed by the MDBs can maximise the impact of China's potential contribution to public financing of the JETPs. For example, the Innovative Finance Facility for Climate in Asia and the Pacific (IF-CAP) is a leveraged guarantee mechanism for climate finance that enables the Asian Development Bank to make more capital available for lending for climate investment in lower-income countries (ADB, 2023). It should be noted that US$1 in public finance invested in an MDB will yield US$5 in additional climate finance, with less paid-in capital required from donors, and demonstrating the value of their paid-in capital.

Coalition of Trade Ministers on Climate

In January 2023, 29 trade ministries from developed and developing countries launched the Coalition of Trade Ministers on Climate. The Coalition had 59 member countries as of February 2024. At its launch, the founding members pledged they would be guided by the following principles:

- **Cooperation** in their contribution to the global response to climate change, including by engaging nationally and internationally with fellow ministers working on climate, environment, finance and development, among others.
- **Inclusivity** in the engagement of ministers and relevant stakeholders from different regions and at different levels of development and climate vulnerabilities.
- **Leadership** in providing high-level political direction and guidance to bolster inclusive cooperation on the nexus of climate, trade and sustainable development.
- **Transparency** for effective climate action built on trust and international cooperation.

The Coalition has identified the following priorities:

- Foster **international cooperation** and collective action to promote trade and trade policies that pursue climate action across the World Trade Organisation and relevant multilateral, plurilateral, regional and sectoral initiatives.
- Identify ways to ensure the **multilateral trading system** contributes to the global response to climate change and promotes a positive contribution to the climate agenda, including through focused attention across sectors on the nexus between climate and trade.
- **Promote trade and investment** that foster the diffusion, development, accessibility and uptake of goods, services and technologies that support climate mitigation and adaptation in both developed and developing countries.
- **Identify trade-related strategies** supportive of the most vulnerable developing and least developed countries.
- **Build alliances** and partnerships with climate and finance communities and relevant stakeholders to foster climate action, transitions and climate-resilient development on the ground.

The principles and priorities of the Coalition are consistent with China's best interests as a leading trade partner in zero-emissions and climate-resilient goods and services around the world. Many BRI countries are members of the Coalition, although few other countries in Asia have joined so far, and there are no ASEAN members.

If China joins the Coalition, and encourages ASEAN members to do the same, it would demonstrate to the world that it recognises the important role of trade policy in promoting the transition to a zero-emissions and climate-resilient economy, and would help to allay concerns in other countries that China's dominance in TCMs and its influence over supply chains pose a threat to the transition.

4. Conclusions

This policy insight has sought to address two key questions:

1. What is China's role in supply chains for renewable energy technologies?
2. How can China support the energy transition in other countries, such as those in the ASEAN region?

China holds a dominant position in the manufacturing and supply chains for clean energy technologies. This has resulted from a combination of strategic government policies coupled with investments by Chinese financial institutions and companies. It has also benefitted from strategic partnerships with BRI countries, including members of ASEAN.

China's dominance has contributed to a geographical concentration of manufacturing and supply chains that creates vulnerabilities to disruption caused by trade restrictions and by extreme events. Climate change is increasing these risks by making many types of extreme weather events more frequent and intense across the world.

Governments are responding to these risks through a range of policies and actions, including strategic plans that designate materials as critical, designed to diversify manufacturing and supply chains. This diversification is potentially beneficial to China, which is also exposed to the consequences of local disruption.

China could ensure that its investments in BRI countries encourage diversification of manufacturing and supply chains for clean energy technologies. The member countries of ASEAN are collectively China's largest trading partners, and the Regional Comprehensive Economic Partnership, which was initiated by the ASEAN countries, is the world's largest free trade agreement. It could strengthen coordination and communication, including with China, to improve the robustness and resilience of manufacturing and supply chains for clean energy technologies. The 'greening' of China's export finance and trade and supply finance could encourage domestic companies to increase their investments in clean energy technologies in the ASEAN region, and accelerate the transition away from fossil fuels.

The Just Energy Transition Partnerships, which have been launched in Indonesia and Vietnam, provide an opportunity for China and the G7 to work together to speed up the transition in ASEAN countries.

China could also join the Coalition of Trade Ministers on Climate, and encourage ASEAN countries to do the same, to demonstrate to the world that it recognises the important role of trade policy in promoting the transition to a zero-emissions and climate-resilient economy. This would also help to allay concerns in other countries that China's dominance in the production of transition-critical minerals and its influence over supply chains poses a threat to the transition.

References

ADB [Asian Development Bank] (2022) *An analysis of the product-specific rules of origin of the Regional Comprehensive Economic Partnership*. www.adb.org/sites/default/files/publication/792391/product-specific-rules-origin-rcep.pdf

ADB (2023a) *ASEAN and global value chains: locking in resilience and sustainability*. www.adb.org/sites/default/files/publication/871976/asean-global-value-chains-resilience-sustainability.pdf

ADB (2023b) Q&A: innovative finance facility for climate in Asia and the Pacific (IF-CAP). Web page. www.adb.org/news/features/qa-innovative-finance-facility-climate-asia-pacific-if-cap

ADB (2023c) ADB, CEXIM sign agreement to support co-financing of private sector investments in Asia and the Pacific. Press release, 26 June. www.adb.org/news/adb-cexim-sign-agreement-support-co-financing-private-sector-investments-asia-and-pacific

Aghion P, Cai J, Dewatripont M, Du L, Harrison A et al. (2015) Industrial policy and competition. *American Economic Journal: Macroeconomics*, 7(4): 1–32. www.aeaweb.org/articles?id=10.1257/mac.20120103

Anadon LD, Jones A, Peñasco C, Sharpe S, Grubb M et al. (2022) *Ten principles for policymaking in the energy transition: lessons from experience*. Economics of Energy Innovation and System Transition. https://eeist.co.uk/eeist-reports/ten-principles-for-policy-making-in-the-energy-transition/

Armstrong S and Drysdale P (2022) The economic cooperation potential of East Asia's RCEP agreement. *East Asian Economic Review*. https://koreascience.kr/article/JAKO202211757495201.pdf

Asia Society Policy Institute (2023) *Strengthening regional supply chain resiliency through the Indo-Pacific economic framework*. https://asiasociety.org/policy-institute/strengthening-regional-supply-chain-resiliency-through-indo-pacific-economic-framework-ipef

Association of Southeast Asian Nations [ASEAN] (2022) High-level forum marks 10 years of RCEP journey. Web page. https://asean.org/high-level-forum-marks-10-years-of-rcep-journey/

Beck S, Kim K, Pandey A, Tayag MC, Latoja MC et al. (2023) *2023 trade finance gaps, growth, and job survey*. ADB Briefs. www.adb.org/sites/default/files/publication/906596/adb-brief-256-2023-trade-finance-gaps-growth-jobs-survey.pdf

Bian L (2023) China's role in scaling up energy storage investments. *Energy Storage and Saving*. https://doi.org/10.1016/j.enss.2023.03.002

BloombergNEF (2022a) China's battery supply chain tops BNEF ranking for third consecutive time, with Canda a close second. Blog post, 12 November. https://about.bnef.com/blog/chinas-battery-supply-chain-tops-bnef-ranking-for-third-consecutive-time-with-canada-a-close-second/

BloombergNEF (2022b) Localizing clean energy value chains will come at a cost. Blog post, 7 November. https://about.bnef.com/blog/localizing-clean-energy-value-chains-will-come-at-a-cost/

Bond K and Butler-Sloss S (2023), *The Renewable Revolution*. RMI. https://rmi.org/insight/the-energy-transition-narrative/

Buchholz W, Dippl L, Eichenseer M (2019) Subsidizing renewables as part of taking leadership in international climate policy: the German case. *Energy Policy*, 129: 765–773. www.sciencedirect.com/science/article/pii/S0301421519301272

Buljan A (2023) China leads in new offshore wind capacity second year in row, likely to preserve top position in 2023. *offshoreWIND.biz*, 20 February. www.offshorewind.biz/2023/02/20/china-leads-in-new-offshore-wind-capacity-second-year-in-row-likely-to-preserve-top-position-in-2023/

Caixin Global (2023) Chinese Belt and Road loans total $687 billion over a decade. *Caixin Global*, 18 October. www.caixinglobal.com/2023-10-18/chinese-belt-and-road-loans-total-687-billion-over-a-decade-102117703.html

Chang HJ and Zach K (2019) Asian transformations: an inquiry into the development of nations. Chapter 8: industrialisation and development. Oxford University Press. https://doi.org/10.1093/oso/9780198844938.003.0008

Cordero T (2023) ADB eyes facilitating Philippines entry into partnership for clean energy shift. *GMA Integrated News*, 14 June. www.gmanetwork.com/news/money/economy/872946/adb-eyes-facilitating-philippines-entry-into-partnership-for-clean-energy-shift/story/

Costa G (2022) China's coal-fired power plants should be terminated over public concerns. *Indonesia Business Post*, 2 November. https://indonesiabusinesspost.com/insider/chinas-coal-fired-power-plants-should-be-terminated-over-some-concerns/

Donaldson A (2023) Vietnam approves energy plan for the next decade, promoting renewables. power technology. *Power Technology*, 16 May. www.power-technology.com/news/vietnam-approves-energy-plan-for-the-next-decade-promoting-renewables/#:~:text=By%202030%2C%20Vietnam%20aims%20to,of%20the%20total%20power%20mix

Economist, The (2023) America is losing ground in Asian trade. *The Economist*, 15 June. www.economist.com/finance-and-economics/2023/06/15/america-is-losing-ground-in-asian-trade

European Union (2023) Regulation of the European Parliament and of the Council concerning batteries and waste batteries, amending Directive 2008/98/EC and Regulation (EU) 2019/1020 and repealing Directive 2006/66/EC, 12 July 2023. http://data.europa.eu/eli/reg/2023/1542/oj

G7 (2023), *Clean energy economy action plan*. www.consilium.europa.eu/media/64502/g7-clean-energy-economy-action-plan.pdf

Galparsoro I, Menchaca I, Garmendia JM, Borja Á, Maldonado AD et al. (2022) Reviewing the ecological impacts of offshore wind farms. *npj Ocean Sustainability*. www.nature.com/articles/s44183-022-00003-5

Global Times (2023) RCEP helps raise customs clearance efficiency, lets SMEs participate in international trade: CCPIT Official. *Global Times*, 17 January. www.globaltimes.cn/page/202301/1283916.shtml

Guarascio F and Nguyen P (2023) Exclusive: Chinese energy storage, battery firms consider big investments in Vietnam. *Reuters*, 8 June. www.reuters.com/markets/asia/chinese-energy-storage-battery-firms-consider-big-investments-vietnam-sources-2023-06-08/

Hou Y (2023) China and ASEAN: cooperating to build epicentrum of growth. Web page. Mission of the People's Republic of China [PRC] to ASEAN. http://asean.china-mission.gov.cn/eng/stxw/202302/t20230221_11028599.htm

IEA [International Energy Agency] (2023a) *The state of clean technology manufacturing: an energy technology perspectives special briefing*. www.iea.org/reports/the-state-of-clean-technology-manufacturing

IEA (2023b) *Global EV outlook 2023: catching up with climate ambitions*. www.iea.org/reports/global-ev-outlook-2023

IEA (2022) *Solar PV global supply chains*. www.iea.org/reports/solar-pv-global-supply-chains

IEA (2021) *Net zero by 2050: a roadmap for the global energy sector*. www.iea.org/reports/net-zero-by-2050

IEA, International Renewable Energy Agency (IRENA) and UN Climate Champions (2022) *The breakthrough agenda report 2022*. www.iea.org/reports/breakthrough-agenda-report-2022

IMF [International Monetary Fund] (2023) *Subsidy wars: cooperation and common understanding could dial back trade tensions*. www.imf.org/en/Publications/fandd/issues/2023/06/B2B-subsidy-wars-elizabeth-van-heuvelen#:~:text=The%20classic%20economic%20argument%20against,resources%20to%20less%20productive%20uses

IMF, Organisation for Economic Co-operation and Development [OECD], World Bank and World Trade Organization (2022) *Subsidies, trade, and international cooperation*. www.imf.org/en/Publications/analytical-notes/Issues/2022/04/22/Subsidies-Trade-and-International-Cooperation-516660

IMF (2021) *G-20 reaching net zero emissions*. www.imf.org/external/np/g20/pdf/2021/062221.pdf

IMF (2019) *Global fossil fuel subsidies remain large: an update based on country-level estimates*. IMF Working Paper WP/19/89. www.imf.org/en/Publications/WP/Issues/2019/05/02/Global-Fossil-Fuel-Subsidies-Remain-Large-An-Update-Based-on-Country-Level-Estimates-46509

Institute for Essential Reform Serviced (2022) *Wind energy acceleration needs supporting ecosystems*. https://iesr.or.id/en/tag/wind-power-plant#:~:text=Jakarta%2C%20July%2025%2C%202022%20%E2%80%93,and%2060.6%20GW%20onshore%20wind

IRENA (2022) *Energy transition investment opportunities in Southeast Asia: a preview of ASEAN and Indonesia findings*. www.irena.org/-/media/Files/IRENA/Agency/Events/2022/Sep/IRENA_Energy_transition_investment_SEAsia_2022.pdf?rev=132cf0efbe8a42de86b97bbdc30c0a36&hash=CA5ABD66066B59ADB91CD07573819CC9

IRENA (2023) *The cost of financing for renewable power*. www.irena.org/Publications/2023/May/The-cost-of-financing-for-renewable-power

Japan Bank of International Cooperation (2022) Joint statement with Asian export and import banks on efforts to address climate change. Press release, 17 November. www.jbic.go.jp/en/information/press/press-2022/1117-016993.html

Jenkins JD, EN Mayfield, J Farbes, R Jones, N Patankar et al. (2022) *Preliminary report: The climate and energy impacts of the Inflation Reduction Act of 2022*, Princeton University – Zero Lab. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://repeatproject.org/docs/REPEAT_IRA_Prelminary_Report_2022-08-04.pdf

Kershaw F (2021) New U.S. quiet technologies should underpin offshore wind. Blog post, 6 September. *Natural Resources Defense Council*. www.nrdc.org/bio/francine-kershaw/new-us-quiet-technologies-should-underpin-offshore-wind

Kleimann D, N Poitiers, A Sapir, S Tagliapietra, N Véron et al. (2023) How Europe should answer the US Inflation Reduction Act. *Bruegel*. www.bruegel.org/policy-brief/how-europe-should-answer-us-inflation-reduction-act

Konig J (2023) What is slowing Vietnam's just energy transition? *China Dialogue*, 9 March. https://chinadialogue.net/en/energy/what-is-slowing-vietnams-just-energy-transition/

Krugman P (2010) *The new economic geography, now middle-aged*. Princeton University. www.princeton.edu/~pkrugman/aag.pdf

Larsen J, B King, H Kolus, N Dasari, G Hiltbrand and W Herndon (2022) *A turning point for US climate progress: assessing the climate and clean energy provisions in the Inflation Reduction Act*. Rhodium Group. https://rhg.com/research/climate-clean-energy-inflation-reduction-act/

Larsen M and Oehler L (2022) *Clean at home, polluting abroad: the role of the Chinese financial system's differential treatment of state-owned and private enterprises*. https://doi.org/10.1080/14693062.2022.2040409

Lim G and Sheng GC (2022) In Indonesia, Chinese financing for coal-fired power plants grows faster than that for renewables. *ThinkChina*, 4 July. www.thinkchina.sg/indonesia-chinese-financing-coal-fired-power-plants-grows-faster-renewables

Leruth L, A Mazarei, P Régibeau and L Renneboog (2022) *Green energy depends on critical minerals. who controls the supply chains?* Working Paper 22–12, Peterson Institute for International Economics. www.piie.com/publications/working-papers/green-energy-depends-critical-minerals-who-controls-supply-chains

LONGi (2021) LONGi supplies 70 MW modules to the largest floating PV plant cluster in Vietnam. Press release, 5 January. www.longi.com/en/news/7008/

Ma J (2020) *Investment and financing models, challenges and recommendations of renewable energy projects by Chinese companies in the Belt and Road Countries*. Tsinghua PBCSF and Greenovation: Hub. www.ghub.org/en/bri-re-report/

Malingrey L and Duval Y (2022) *Mainstreaming sustainable development in regional trade agreements: comparative analysis and way forward for RCEP*. United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP). Asia-Pacific Research on Training Network for Trade Working Paper 213. www.unescap.org/kp/2022/mainstreaming-sustainable-development-regional-trade-agreements-comparative-analysis-and

Ministry of Commerce of People's Republic of China [MOFCOM] (2020) *Regional Comprehensive Economic Partnership (RCEP) agreement: Chapter 18 on institutional provisions*. http://fta.mofcom.gov.cn/rcep/rceppdf/d18z_en.pdf

Miroudot S (2020) Resilience versus robustness in global value chains: Some policy implications. Web page. Centre for Economic Policy Research. https://cepr.org/voxeu/columns/resilience-versus-robustness-global-value-chains-some-policy-implications

Nedopil C (2023a) *China Belt and Road Initiative (BRI) investment report 2022*. Green Finance & Development Center, FISF Fudan University. https://greenfdc.org/wp-content/uploads/2023/02/Nedopil-2023_China-Belt-and-Road-Initiative-BRI-Investment-Report-2022.pdf

Nedopil C (2023b) *China Belt and Road Initiative (BRI) Investment Report 2023 H1*. Green Finance & Development Center, FISF Fudan University. https://greenfdc.org/wp-content/uploads/2023/07/Nedopil-2023_China-Belt-and-Road-Initiative-BRI-Investment-Report-2023-H1-1.pdf

Nguyen T (2022) Vietnam's economy to benefit most from RCEP: World Bank. *Vietnam Briefing*, 14 April. www.vietnam-briefing.com/news/vietnams-economy-benefit-most-from-rcep-world-bank.html/

OECD (2022) *ASEAN SMEs' integration in global value chains (GVCs): Opportunities and challenges in response to COVID-19*. www.oecd.org/southeast-asia/ASEAN%20SMEs%20Integration%20in%20GVCs_F.pdf

Park CY, Petri PA and Plummer M (2021) *Economic implications of the Regional Comprehensive Economic Partnership for Asia and the Pacific*. ADB Economics Working Paper 639. www.adb.org/sites/default/files/publication/740991/ewp-639-regional-comprehensive-economic-partnership.pdf

Peter M and Downie C (2023) *The international political economy of export credit agencies and the energy transition*. Review of International Political Economy. https://doi.org/10.1080/09692290.2023.2272845

Rapid Transition Alliance (2023) Viet Nam's rapid rise to becoming a solar powered state. Web page. https://rapidtransition.org/stories/viet-nams-rapid-rise-to-becoming-a-solar-powered-state/

Reuters (2023) Indonesia sees record coal exports of more than 500 mln tonnes in 2023. *Reuters*, 30 January. www.reuters.com/business/energy/indonesia-sees-record-coal-exports-more-than-500-mln-tonnes-2023-2023-01-30/

Reuters (2021) EV battery maker CATL plans $5-billion China recycling facility, *Reuters*, 12 October. www.reuters.com/world/china/ev-battery-maker-catl-plans-5-billion-china-recycling-facility-2021-10-12/

Rockefeller Foundation (2023) The Rockefeller Foundation and GEAPP to design the world's first 'coal-to-clean' credit program in emerging economies. Press release, 14 June. www.rockefellerfoundation.org/news/the-rockefeller-foundation-and-geapp-to-explore-the-worlds-first-coal-to-clean-credit-program-in-emerging-economies/

Roesad K (2023) Indonesia's underwhelming renewable energy reform. *East Asia Forum*, 11 April. www.eastasiaforum.org/2023/04/11/indonesias-underwhelming-renewable-energy-reform/

Setzer J and Higham C (2023) *Global trends in climate change litigation: 2023 snapshot*. Grantham Research Institute on Climate Change and the Environment at London School of Economics and Political Science. www.lse.ac.uk/granthaminstitute/wp-content/uploads/2023/06/Global_trends_in_climate_change_litigation_2023_snapshot.pdf

Springer C, Ratan I, Liu Y and Gu J (2023) *Green horizons? China's global energy finance in 2022*. Boston University Global Development Policy Center. www.bu.edu/gdp/files/2023/11/GCI_PB_020_CGEF_FIN.pdf

State Council (2021) China's central bank emphasises supply chain finance development. Web page. https://english.www.gov.cn/statecouncil/ministries/202106/01/content_WS60b61907c6d0df57f98da86b.html

State Council Information Office [SCIO] (2022) *China accounts for 30% of global manufacturing output: Official*. http://english.scio.gov.cn/pressroom/2022-06/14/content_78269516.htm

SCIO (2023) *SCIO briefing on China's import and export of 2022*. http://english.scio.gov.cn/pressroom/node_9000408.htm

Stern N (2023) *Harnessing creative destruction to the tackling of climate change: purpose, pace, policy. In Akcigit U and Van Reenen J (eds.) The Economics of Creative Destruction New Research on Themes from Aghion and Howitt*. Harvard University Press. pp.365–397. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.production.hup.harvard.edu/file/feeds/PDF/9780674270367_sample.pdf

Taylor-Strauss H (2021) *Leveraging RCEP to boost sustainable FDI*. UNESCAP. www.unescap.org/sites/default/d8files/event-documents/SEA%20SDG%20Forum%20Session%206_RCEP%20and%20FDI_share.pdf

Thai PBS World (2023) ASEAN sets up interim RCEP bureau. *Thai PBS World*, 5 February. www.thaipbsworld.com/asean-sets-up-interim-rcep-bureau/

Thangavelu S, Urata S and Narjoko (2021) *Impacts of the Regional Comprehensive Economic Partnership on ASEAN and ASEAN least developed countries in the post-pandemic recovery*. Economic Research Institute for ASEAN and East Asia. www.eria.org/uploads/media/policy-brief/Impact-of-RCEP-in-ASEAN-post-pandemic-recovery-new.pdf; www.eria.org/uploads/media/policy-brief/Impact-of-RCEP-in-ASEAN-post-pandemic-recovery-new.pdf

UNCTAD [United Nations Conference on Trade and Development] (2022) *ASEAN investment report 2022*. https://unctad.org/publication/asean-investment-report-2022

UNCTAD (2023) *Technology and innovation report 2023*. https://unctad.org/publication/technology-and-innovation-report-2023

United Nations Environment Programme (2022). *Emissions gap report 2022: The closing window – Climate crisis calls for rapid transformation of societies*. www.unep.org/emissions-gap-report-2022