# De-risking and decarbonising:

energy goods is a global public good; all countries gain when others cut emissions, and all su er from climate change if decarbonisation is delayed. Yet this trade depends on China, which controls most of the world's prodt lu [illegible] should share technolo China and from sourcing than is still cheaper than reshoring. China would have more room to use its clean tech to meet its own decarbonisation targets.

be organised through a combination of trade and investment agreements, together with tech transfer and nancial agreements, under some form of inter-governmental oversight. e dependence of all countries on China for green tech is so great that non-market incentives might also be needed, such as subsidies or, preferably, a system of carbon pricing within the partnership.

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# 1 Introduction

Despite rising geopolitical tensions, Europe, the United States and China agree on one goal: the need for all countries to replace fossil fuels with renewable energy, in order to cut the greenhouse gas emissions that are causing global warming. However, it is difficult to cooperate on green tech trade in the context of geopolitical tension and geo-economic competition. Even worse, the scramble for critical resources to make the clean tech needed for decarbonisation is creating new tensions, becoming another source of rivalry.

To pursue decarbonisation as a global public good, greater alignment of the major economic powers is needed around a collective effort to accelerate the transition to renewable energy and electric vehicles. China wants to maintain its dominant position in global supply chains, while the US and European Union are focused primarily on increasing their own supplies of clean tech, rather than improving the overall security of supply for all countries.

We analyse two main risks to faster global decarbonisation. The first stems from the excessive concentration of green-energy supply chains in a single country. China dominates global supply chains for green-energy products, including solar panels, electric vehicle batteries and, to a lesser extent, wind turbines. For Europe to reduce this risk, supplementary supply chains would need to be built, rather than just reshoring critical raw materials and production, which has been the main theme of recently announced EU policies (Tagliapietra *et al*, 2023; Le Mouel and Poitiers, 2022). The second risk arises from China's own clean-tech needs. China's decarbonisation targets are a vital global interest because it is the largest emitter of greenhouse gases. Given China's massive investment in production capacity for renewables, the risk that China might be unable to supply sufficient green tech to the rest of the world appears currently to be low, but this risk could grow, and supply disruptions that would slow down global decarbonisation remain a problem.

To address both risks, a 'green tech partnership' should be put in place. This would be a network of countries that take responsibility for different parts of the supply chain, according to their comparative advantage – in other words, through coordinated specialisation. It aims at creating a supplementary supply chain that would increase the production of green tech over and above that of China, while ensuring that extraction, refining and innovation are less concentrated in a single country.

The main challenge in designing such a partnership is how to align incentives for the governments and private sectors of participating countries, and how to keep it inclusive. In other words, the aim is not to substitute the China-centric green supply chain, but to complement it by calling into the partnership resource-rich countries and those with innovation capabilities or low-cost extraction, refining or manufacturing infrastructure.

We first review Europe's dependence on China for decarbonisation goods and provide data on China's own needs for clean tech in the future, which will affect its export capacity. Next, we assess recent European and American attempts to reduce this reliance on China through the reshoring of production and seeking of bilateral deals with countries that can offer alternative raw material supplies. Neither the current situation of reliance on China nor the attempts at reshoring production are the best options for minimising the risks to global decarbonisation. We then set out our proposal for a green tech partnership.

Beyond domestic extraction of key minerals, China commands a network of mineral supply agreements that feed its domestic refining industry, built through a series of cross-border acquisitions and trade agreements. These are primarily in southern and western Africa, Oceania and Latin America, but also with regional neighbours (Holden *et al*, 2022). China dominates the processing of REEs, with a market share above 85 percent, and of silicon and cobalt, all of which are integral to the production of high-energy-density batteries, wind turbines and solar panels[1].

[illegible] *Politico* [illegible] https://www.politico.eu/article/white-gold-rush-salt-lithium-batteries-raw-

That China's share of metals processing is higher than its share of extraction of those metals is a good indicator of how strategic the Chinese government has been in its long-standing aim to achieve dominance of the clean-tech industry. The US, EU and other advanced economies were for years content to see the processing of critical raw materials move to China because it is environmentally damaging and often depletes groundwater resources[2]. It would now be difficult for them to re-shore processing on a large scale because of domestic political opposition.

## 2.2 China is an advanced manufacturer of renewable energy goods

Much of Chinese manufacturing today is technologically advanced and grounded in a unique political, educational and infrastructural ecosystem. Economies of scale and leveraging of big

## Figure 5: Solar PV e□ciency records, crystalline silicon*

Source: NREL. Note: The figure shows the location of laboratories that have broken e□ciency records for crystalline silicon solar panels over the last five decades. Chinese researchers have begun setting records in the last decade. Crystalline silicon solar modules are the most prevalent on the market. E□ciency refers to the share of energy received converted into electricity.

Chinese rms are the trusted suppliers of the European solar installation industry. More than 96 percent of EU imports of solar panels came from China in 2022, with a high degree of dependence across the whole supply chath hole sith a hiolth6n81tab in 20,an s1 (ole i(oz3s)-.1 (ta)8 (b e n

## Figure 7: Solar PV e□ciency records, all technologies (EU, US, China)

Source: NREL. Note: See note to Figure 5.

For instance, in the development of solar PV cells that incorporate perovskites[4], China lags behind other producers (Figure 8). ere is a clear potential for a commercial breakthrough of solar panels produced with perovskites, which are considerably more e cient than currently dominant single-layer crystalline silicon panels, but scalability may be di cult outside China without government intervention.

## Figure 8: Solar PV e□ciency records, perovskite

Source: NREL.Electric batteries.

### EV batteries

Global EV lithium-ion battery production is principally located in China, Japan and Korea, with China having a 60 percent market share in 2022 (Figure 9). However, following major investments in EV battery factories in geographies including the EU and the US, manufacturing will become increasingly regionalised. Nevertheless, mineral extraction and re ning may be harder to diversify and will likely remain centred on China in the near term.

https://www.energy.gov/eere/solar/perovskite-solar-cells-

Figure 9: Market share of lithium-ion EV battery production by country

Source: Bruegel based on Natixis, SNE Research.

## Figure 11: Shares of global wind turbine manufacturing

Source: Natixis.

ough EU-China trade in nished wind turbines is low, there is a sizeable volume of trade in intermediate turbine components (Figure 12). While the EU's reliance on China is generally only moderate for most components, 91 percent of EU imports of permanent magnets came from China in 2022, a dependence that extends to many other technologies, including electric motors[5].

## Figure 12: EU dependence on China in the wind turbine supply chain (2022)

Source: Eurostat.

https://thechinaproject.com/2023/07/25/chinas-wind-power-companies-are-giants-but-they-arent-going-to-take-over-the-world-yet/ *Quartz* https://qz.com/1999894/why-rare-earth-magnets-are-vital-to-the-global-climate-economy *Wind Systems Magazine* https://www.windsystemsmag.com/applications-of-magnets-in-wind-turbines/-

## 2.3 China's increasing dominance of green tech-related innovation

Chinese researchers have rapidly increased their output of scientific publications on solar PV, wind turbine and EV battery technologies, surpassing the US and the EU in 2022 (Figure 13). Currently, Chinese firms mainly lead on manufacturing processes and cost efficiency. By investing in domestic research on renewable energy technologies – where the West still mainly holds the lead – Chinese firms aim to reinforce their grip on exports of these goods. However, the quantity of output tells little of its quality, and the extent to which this research is novel and what share of it is applied as opposed to basic is not reflected in this breakdown.

### Figure 13: Chinese scientific publishing on renewable energy tech

| | Number of scientific publications - 2010 | | | Number of scientific publications - 2021 | | |
|---|---|---|---|---|---|---|
| | 1st | 2nd | 3rd | 1st | 2nd | 3rd |
| Solar |  | | | | | |
| | | | | | | |
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| | | | | | | |

Figure 14: Solar PV installed capacity for net-zero, by region

Source: Bruegel based on IRENA, IEA.

## 3.1 China will need a massive increase in renewable energy capacity to meet its targets

While China has steadily cemented its dominant role as the largest exporter of green tech globally, the country's own decarbonisation needs are vast. It is the world's largest greenhouse gas emitter and has targets of peaking emissions in 2030 and reaching net zero by 2060.

Over the last two decades, China has addressed its rapidly growing energy needs by expanding its coal energy infrastructure (Figure 17). is expansion, which is still ongoing[6], will need to cease and ultimately be reversed through substitution by non-fossil power generation. is will require China to expand its renewables base on an enormous scale if its energy supply is to remain su cient while emissions are being cut and if its decarbonisation targets are to be delivered on time.

### Figure 17: China, total energy consumption by source

Source: China National Bureau of Statistics. Note: the unit of measurement is quad BTU (quadrillion British thermal units). One quad BTU is roughly equivalent to one exajoule (EJ) of energy. Global primary energy consumption was 617 EJ in 2019 (https://www.iea.org/reports/world-energy-balances-overview/world).

China's renewable energy needs are highly dependent on how its *per-capita* energy demand de (e)-3wuopgaxo decadesseinonghld ao(b)-1.9denerateasJ is

Despite this, the Chinese solar PV industry remains predominantly geared towards exports, with only about a third of total supply installed domestically (Figure 19). is is despite China's large reliance on coal, phase out of which is a global priority. In a scenario in which China is pushed to install renewables even faster, for instance a climate crisis, there is a major question about whether China could remain the globally predominant supplier while addressing its domestic needs. e answer will depend on investment decisions made today, which are subject to a number of factors, including the return on investment in the various renewable sectors in China.

### Figure 19: Chinese solar PV exports vs domestic installation, GW

Source: Bruegel based on IRENA, Wood Mackenzie.

Chinese installation of solar PV has accelerated in the last three years, and is projected

semi-conductors to the rest of the world, causing sharp increases in chip prices[10]. is type of *force majeure* event can cause immense disruption to global trade, and are a much bigger risk if there is heavy concentration of supply chains in single countries.

Among the second group of risks associated with decisions made in Beijing, there are two broad categories: economic policy and political decisions. Among the former, China's own decarbonisation e orts gure most prominently. e country's domestic needs are considerable and will require a ramping up of production capacity and consistent pace of expansion of renewable energy infrastructure (section 3.1). At the moment, Chinese production is growing in response to increasing global demand. However, at some point, it might become di cult to meet the EU's demand for decarbonisation goods if China cannot invest enough to keep on growing the supply of renewables, or decides to put its own needs rst or serve other trading partners with which it may have signed preferential agreements.

e second type of decision made by Beijing is retaliation. ere are clear instances, some very recent, of potential green-tech relation from China. For example, the introduction by the Netherlands of export controls on semiconductor components (lithography machines) in 2023 provoked retaliation by China in the form of a stop to exports of gallium and germanium, which are essential inputs into high-end semi-conductors[11]. China previously leveraged its dominant position in the minerals supply chain in 2010 when it stopped rare earth element exports to Japan after a stand-o over disputed islands[12] needed to respond to the risks of excessive reliance on China, these two proposed laws are unfortunately unlikely to achieve this goal.

 e CRMA would set targets for domestic mining, re ning and recycling that are unlikely to be achieved because reshoring would be expensive and, in some cases, unfeasible because of European environmental protection rules. Furthermore, the bottlenecks in the supply chain for di erent types of green tech are so large that the EU's dependence on China cannot be solved exclusively through more access to re ned critical raw materials. Even with such access, which so far remains elusive, reshoring the manufacturing of solar panels would not be cost e ective, thus, driving up prices of clean tech and making the energy transition even more costly.

European countries might also increase costs even further by implementing narrowly de ned plans to secure critical raw materials for their own use, instead of sharing the procurement for the whole EU or beyond. Le Mouel and Poitiers (2023) proposed that the EU creates an international strategy for critical raw materials, using instruments such as investment and export credits to diversify global supply chains.  is is a worthy aim, but would take much longer than the timescale allowed for the energy transition.  e lead times for mining projects are very long, with a global average of 17 years, while new re ning plants can be built more quickly but can still be a major bottleneck (Energy Transitions Commission, 2023). Moreover, the EU's negotiation of trade agreements tends to be extremely slow, and rati cation can run into political opposition. All in all, a rapid building up of access to CRMs seems unrealistic for the EU to achieve alone.

 e most recent innovation in EU green industrial policy, the proposed NZIA, aims to encourage domestic manufacturing, mainly by easing permitting and setting a 40 percent self-su ciency target for clean-tech sectors. However, this target is unlikely twems for cy h.4416 ()-4 (e cosn)4

Figure 22: Solar PV module manufacturing cost per region, $/watt

Source: Wood Mackenzie.

## 5 A novel approach: from reshoring to a green tech partnership

While reshoring the production of renewables would be very costly and may not be feasible in a reasonable amount of time, a green tech partnership could serve the purpose of derisking

(ii) lowering the cost of reduced reliance on China compared to alternative approaches, such as the great bene t of reducing the costs of green tech. However, the downside is that such high concentration discourages innovation in new technologies. Members of a green tech partnership would have an interest in leapfrogging existing technologies to create even more cost-e ective alternatives. is would be bene cial not only for the members of the partnership, but for the world as a whole. e current relatively limited competition means dependence on speci c technologies that are narrowly controlled by a single country. By contrast, the existence of two or more main supply chains that are jointly innovating, as well as competing to reduce production costs even further, helps everyone.

Even though China would not be a member, the green tech partnership would not be a threat to China's exports of clean-tech products, because the demand is set to grow so much that all global production will be needed. However, China would also bene t from the technological diversi cation the partnership could generate, given that Chinese producers are also dependent on raw materials that may not be available in su cient quantities, even from the supply chains China currently dominates. Examples are the silver required for solar PV in current technology, and the lithium required for batteries for electric vehicles. In these cases, the only way out of raw material shortages is technological substitution. Chinese producers can and are developing new technology that uses other raw materials, but innovation is more likely to succeed when many scientists and companies work in parallel in many countries. China should not fear the creation of alternative technologies that will compete with its products, because the ft(a)7 (1m47 (us)- m)7 (i1 (o 1h)7 ( (y e climate clubs has evolved over time. Originally put forward by William Nordhaus in 2015 (Nordhaus, 2015), several proposals have appeared since around the idea of groups of coun-

### 6.2 Tools to align incentives

# 7 Conclusions

European Commission (2023b) 'Net Zero Industry Act', COM(2023) 161, available at httpsn o-4 Y73 cm0 GS0 gs[h)7 (t)3 (tp