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Author

Mazzocco, Ilaria

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Domestic Incentives and the Internalization of Chinese Manufacturing in the Wind, Electric Vehicle, and Battery Industries

Ilaria Mazzocco

Abstract

Chinese firms are leading players in the production of clean energy technologies and appear set to expand further. This paper analyzes trends in Chinese clean tech manufacturing including internationalization, and the outlook for manufacturing facilities outside of China in the clean energy technology industry, including EVs, batteries, and wind turbines. Among the main findings: Chinese clean energy technology companies have been relatively quick to expand their foreign market share but production outside of China is still lagging. Europe is likely to be the preferred destination for Chinese battery, EV, and wind companies but current investments are limited to the battery industry. The production of different technologies is subject to different sets of incentives including cost and political considerations that will determine how quickly companies will internationalize production. Overall, the diversification of production would bolster the resilience of supply chains and economic development but is likely to proceed more quickly for batteries and more slowly for other technologies.

Keywords: China, renewable energy, technology, industrial policy, manufacturing

Author

Ilaria Mazzocco

Center for Strategic and International Studies

Email: imazzocco@csis.org

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Introduction

China's industrial policy and the country's position in global supply chains have been objects of research for several years. However, few studies have systematically explored when and how Chinese manufacturing in emerging industries internationalizes. Clean energy technologies are an especially salient case study given their role in climate policy and their rapid adoption globally. Chinese firms in these industries are also leading players internationally and appear set to expand further. Industries such as solar, wind, and electric vehicles (EVs) also provide clear examples of emerging sectors that have thrived due to state support and for which demand is expected to grow globally. Finally, increasing trade tensions over the concentration of manufacturing for some of these technologies in China may be assuaged should there be more diversification from Chinese companies themselves.

The persistent concentration of supply chains in China, even when companies have a clear incentive to relocate internationally, like in the case of solar, raises the questions of why firms do not expand manufacturing more outside of China and under what conditions Chinese firms do choose to internationalize production. A second-order question is whether the high concentration of manufacturing in China of Chinese companies is due to distortions caused by decades of industrial policy. In other words, can firms maintain the same manufacturing cost advantage outside their home country, especially if part of that advantage is the result of explicit industrial policy?

The answer could have implications for international development and the diversification of supply chains: If Chinese companies cannot replicate the unique cost advantages available in the Chinese manufacturing ecosystem, will they forgo localizing production as their international markets expand? The question matters because of Chinese firms' centrality in global supply chains for clean energy technologies and rising political tensions due to the perceived concentration of manufacturing jobs and benefits in China. It also comes at a time when many countries are looking to enhance their manufacturing base through government intervention, including local production requirements. The answer also holds implications for understanding how manufacturing in clean energy technologies might spread and whether it will contribute to creating "green jobs" internationally.

The challenge in conducting this research is two-fold: Many projects are very recent and still in progress, and restrictions introduced to control COVID-19 have restricted access to China and limited the opportunities for fieldwork. This paper aims to provide an up-to-date overview of Chinese EV, battery, and wind manufacturing facilities overseas (including those in the planning stages) and analyzes trends and likely outcomes. It also

investigates the push and pull factors that lead companies to expand their presence in foreign markets without seeking to invest in production overseas and how this compares to non-Chinese firms in the same industries.

China and the clean energy industry are not necessarily unique. There is a rich literature in economics and international political economy exploring the reasons why firms choose to set up production facilities outside their home market. Historically, some of the motives have included the following:

- (1) Local market access and customization has allowed many companies to cater to market-specific demands. Moreover, it usually follows a surge in sales in the host country, which makes the venture more attractive.¹ There are some incentives for EV firms to localize production in regions like Europe and Southeast Asia to respond to local demand more effectively—but this will likely only happen if sales in those regions increase significantly.
- (2) Trade tariffs and regulatory barriers are another powerful motivation for companies to change or expand the location of production.² In the case of clean energy technology, the expansion of Chinese solar firms in Southeast Asia, including Malaysia and Vietnam, is at least partially a response to tariffs imposed by the United States on imports from China. However, most solar firms remain highly reliant on inputs produced in China.
- (3) Related to regulatory barriers but operating as positive incentives are those local content requirements linked to services such as financing, tax credits, permitting, or subsidies. The aim is generally to convince companies to source certain components or manufacture a share of the final product in the host country. Local content requirements can violate WTO rules and have been a consistent source of contention in the international trading system. However, they have been used extensively to varying degrees of success. China's own wind industry benefitted early on from these types of policies. The Inflation Reduction Act, which became law in the United States in 2022 also includes such localization requirements.
- (4) Multinational corporations may locate some production closer to the end market to reduce transportation costs. This is particularly important when inputs are particularly heavy and can be sourced or assembled close to the market. Western wind turbine producers have followed this trend, but Chinese ones so far have not. The desire to be closer to their customers, EV

1 Johanson and Vahlne, "The Internationalization Process of the Firm—A Model of Knowledge Development and Increasing Foreign Market Commitments."

2 Li et al., "Outsourcing Decision-Making in Global Remanufacturing Supply Chains."

manufacturers, appears to be a major driver for Chinese battery companies as they expand their presence in Europe, given the weight and costs associated with shipping batteries.

- (5) Companies may also choose to rebrand as a local firm for a variety of reasons ranging from smart public relations to political necessity. Automotive companies, especially Japanese ones, have followed this approach in the United States with success. Chinese EV and battery firms may come under pressure to follow a similar strategy. Companies may also seek to diversify production to reduce the risk associated with overly concentrated supply chains in a single country. This kind of diversification strategy is increasingly a topic of conversation in boardrooms across the globe.
- (6) Accessing advanced technology is also a powerful motivator for some companies to internationalize.³ This is particularly relevant for Chinese firms that have been seeking to catch up with international companies in more established technologies like autos or wind power. One particularly effective mode of accessing new technology is to acquire an existing company (like in the case of Geely's acquisition of Volvo). A less direct mode is to establish R&D or manufacturing plants in advanced manufacturing and R&D regions to integrate with and learn from other players.
- (7) Last but not least, companies sometimes relocate production closer to cheap inputs. In the case of clean energy technologies, the availability of cheap steel and other commodities in China could be an incentive to keep manufacturing in the country rather than seek to internationalize production.

There is also a growing body of work investigating various aspects of China's commercial internationalization, business-state relations, and their impact on global supply chains. For example, the role of the state and global dynamics in enabling China's rise as a technological power and more specifically a clean energy technology manufacturing power has been well documented.⁴ The patterns of internationalization of Chinese firms also highlight how much companies' motivations and relations with the Chinese government can vary.⁵ In the area of clean tech, scholars have analyzed the interconnectedness of supply chains and innovation systems.⁶ When it comes to China's impact internationally, there has been some work on solar photovoltaic firms and

3 Deng, "Outward Investment by Chinese MNCs."

4 Nahm, Collaborative Advantage; Naughton, *The Rise of China's Industrial Policy, 1978 to 2020*; Lewis, "Green Industrial Policy After Paris"; Lewis et al., "The Development of China's Wind Power Technology Sector"; Naughton and Tsai, *State Capitalism, Institutional Adaptation, and the Chinese Miracle*.

5 Rithmire, "Going Out or Opting Out?"

6 Davidson et al., "Risks of Decoupling from China on Low-Carbon Technologies."

opportunities for tech transfers.⁷ In the case of wind turbine manufacturers, some comparisons have also been drawn between the international expansion of Chinese firms and that of European companies.⁸ However, there is remarkably little work on comparing the internationalization patterns of Chinese firms in the clean energy technology industry more broadly.

Automotive and wind companies have traditionally expanded manufacturing in locations close to large markets. As Chinese companies increase their global market share, they may come under similar pressure to localize. Perhaps even more importantly, clean energy technology supply chains and their concentration within China are coming under increasing scrutiny as more countries seek to gain some economic benefit from investments in decarbonization and analyze their exposure to risk. If Chinese firms were to diversify production this could assuage fears of overreliance on Chinese supply chains and earn political goodwill abroad thanks to rising employment and investment in host countries.

By exploring current trends in Chinese manufacturing and incentive structures, this paper finds that overall, there is still little evidence of widespread internationalization of Chinese manufacturing in the clean energy space, especially outside the photovoltaic industry. The latter is by far the most internationalized, and yet most upstream components are produced in China. The battery and EV industries are more likely to move some production closer to their end markets, especially in growing markets such as the EU, but this trend is still in its early stages and will likely depend on the growth of the market. Instead, the wind turbine industry is far less likely to relocate or diversify manufacturing or source components from outside of China due to the remarkable cost savings that come from relying on integrated Chinese supply chains. Given that some of those supply chains have been shaped by industrial policy over the past few decades, it appears that in sectors past or current state intervention may change traditional patterns and make it less likely that manufacturing will expand to countries outside of China.

The paper will proceed as follows: The first section will provide a short introduction to trends in Chinese manufacturing and the internationalization of Chinese firms. Then it will analyze the domestic expansion, internationalization, and outlook for manufacturing facilities outside of China in the clean energy technology industry, including EVs, batteries, and wind turbines. Finally, the conclusion will include considerations for policy implications and areas of future research.

7 Jackson, Lewis, and Zhang, "A Green Expansion."

8 Lacal-Arántegui, "Globalization in the Wind Energy Industry"; Patey, "Wind and Wires"; Mazzocco, "Chinese Wind Industry Growing Competitive, but Unlikely To Dominate."

Internationalizing Chinese Manufacturing?

Chinese manufacturing overseas is not a new phenomenon and is well documented in Africa and Southeast Asia.⁹ In some cases, Chinese factories serve local markets (including supplying Chinese infrastructure companies), while in others they exploit lower production costs to export internationally. The expansion of assembly plants and textile manufacturing in countries with lower labor costs is consistent with the “flying geese” theoretical framework whereby lower-end manufacturing gradually relocates to countries with cheaper and abundant labor. However, there are still limited instances of Chinese companies opening high-value-added manufacturing plants overseas. The EV and battery industries may help fill this gap. Lithium battery maker CATL built a factory in Germany to supply the European EV market, which reportedly started production in late 2022. BYD also owns an electric bus and battery assembly plant in California, for example.

When it comes to the expansion of manufacturing in the clean energy technology industries, Chinese manufacturers of solar photovoltaic modules have been by far the most visible actors. Their expansion has predominantly taken place in Southeast Asia, especially Malaysia, which is now second worldwide in terms of manufacturing capacity for solar cells after China. Trade restrictions imposed by the United States on solar panels made in China, including those resulting from concerns over forced labor in Xinjiang, were the leading driver of this trend. However, much of the supply chain remains firmly located in China, a fact that continues to drive controversy and nearly led to the imposition of tariffs on imports from several Southeast Asian countries.¹⁰ According to a 2022 International Energy Agency (IEA) report, China’s share in key manufacturing for photovoltaic panels is over 80%.¹¹

It should be noted that Chinese internal combustion engine vehicle manufacturers have also localized in some instances to better serve the local market. The trend has largely taken place in emerging markets where Chinese cars are more popular (for example SAIC owns an MG factory in India and BAIC operates an assembly plant in South Africa). However, up to now, the trend has been limited to lower-cost vehicles and often limited to assembly rather than production and R&D.

9 Yunnan et al., “Learning from China?”; Tang, “Chinese Manufacturing Investments and Knowledge Transfer”; Park and Tang, “Chinese FDI and Impacts on Technology Transfer, Linkages, and Learning in Africa.”

10 Reuters, “Biden to Exempt Tariffs on Solar Panels from Southeast Asian Countries for 24 Months.”

11 “The World Needs More Diverse Solar Panel Supply Chains to Ensure a Secure Transition to Net Zero Emissions.”

In the EV and battery industries, however, Chinese firms are operating at the innovation frontier and directly competing with established multinationals in China and may do so in other markets as well in the coming years. China's impressive economies of scale and manufacturing ecosystem, which has benefitted from decades of industrial policy, do not necessarily overturn the traditional motivations for localization but they could reshape incentives under certain conditions.

The Industries

Before analyzing how Chinese clean energy companies are investing abroad, it is worth taking a step back to understand how their industries emerged and how they compare to their international competitors. This is important because as we will see, while internationalization remains limited, any future prediction depends at least in part on industry patterns and incentives.

Electric Vehicle and Battery Manufacturing

The expansion of the EV industry in China over the past decade has outpaced all expectations and baffled observers in and outside of China. The government's support for the industry was crucial in both creating a stable demand and stimulating production. It also catalyzed the growth of the battery industry, transforming Chinese firms like CATL into global leaders. What started as a small pilot program led by the Ministry of Science and Technology to incentivize a technology with the potential to allow Chinese companies to leapfrog established multinationals and gain a first-mover advantage in international markets has succeeded on multiple levels. Today almost half of the world's stock of EVs is in China according to data from the IEA. Most of those vehicles are made in China and many are Chinese brands. Chinese EV models are now competing directly with international brands in the Chinese market, something that domestic internal combustion engine vehicle manufacturers have struggled with for decades.

A multi-pronged approach based on local government industrial policy attracted a flood of investments and expanded the Chinese market, providing a powerful incentive for battery manufacturers—a key component. The relative slowness of non-Chinese automotive companies to embrace battery-powered vehicles also meant that domestic manufacturers benefited from a remarkably open playing field in the years leading up to the adoption of the so-called Dual Credit Policy that has pushed all firms in China to

invest in EV production.¹² Thus, firms were able to build brand recognition and refine their products without direct competition from established players like Volkswagen and GM until recently.

The market has, however, from the start been marked by high levels of competitiveness. As demand has increased, so has the number of brands and the quality of their offerings, meaning that companies are still fiercely vying for market share. This, in turn, means that consumers have had a growing number of high-quality options, helping expand the market further. The level of enhanced competition within China may be also one of the reasons why companies have felt compelled to expand internationally. Just like in the case of solar panels and wind turbines, competition is also a powerful force in lowering prices by forcing companies to find ways to reduce production costs to undercut competitors.

The cost of EVs is highly correlated to that of batteries, which are a core component. Greater economies of scale, driven by the remarkable growing demand in China, have enabled a decline in costs of batteries and EVs even as quality increases. However, the cost of batteries is highly dependent on global commodities like lithium, meaning that the cost advantage of production in China may be lessened.

Ultimately, if Chinese firms want to become global multinationals, they will need to establish themselves more firmly in foreign markets and engage directly with consumers and regulators outside of China. As of now, while successful in China, the largest automotive market in the world, they remain fairly untested abroad. The expansion of sales and plans for manufacturing in foreign markets, most notably Europe, could be an important factor shaping Chinese EV companies' future.

The growth of the battery industry in China follows closely that of EVs, and industrial policies were largely linked in the 2010s. Incentives for vehicles were directly linked to battery performance, indirectly putting pressure on battery manufacturers to upgrade their products as demand expanded. But state support measures didn't stop at subsidies, or even R&D support. Companies like CATL also benefitted from perfectly timed discriminatory government policies.

In 2016, leading foreign battery makers like LG and Panasonic were not included in the catalog of approved battery manufacturers issued by the Ministry of Industry and Information Technology. The catalog was important to determine eligibility for purchase subsidies for EVs, so auto companies quickly switched to Chinese battery manufacturers

¹² American EV maker Tesla is a notable exception, but the brand has until recently targeted only the luxury segment.

including CATL. By the time the catalog system changed in 2018, contracts and supply chains had changed and CATL had improved its quality and scale to meet the standards of international EV makers. This is important because it helps explain how CATL established such strong relationships with international manufacturers.

Moreover, the leading companies in the sector like CATL and CALB have benefitted from relatively high barriers to entry and a strong advantage from economies of scale. In other words, the battery industry is far less fragmented than the EV sector, with fewer companies that can capture more of the benefits from government policies or market growth.

The Chinese Wind Industry

The wind turbine manufacturing industry was one of the first clean energy technologies actively promoted by the Chinese state beginning in the late 1990s. The government deployed a mix of demand-side and supply-side incentives including support to firms—a strategy that was deployed in other industries and was later replicated for EVs.¹³ Wind turbine manufacturing was also catalyzed through aggressive localization requirements for foreign firms to access the Chinese market, reaching 70% in 2005.¹⁴ By the time the requirements were canceled in 2009, foreign companies had built up extensive manufacturing capacity within China—something that continues to shape value chains today.¹⁵

Since then, Chinese firms have continued to grow, taking full advantage of the large domestic market. In 2021 half of all new wind power installations were in China according to data from the Global Wind Energy Council and almost 40% of all wind power installed capacity was in China. Given this trend, it should come as no surprise that Chinese turbine manufacturers are global leaders. In 2021, according to Bloomberg New Energy Finance, six out of the top ten global turbine manufacturers by commissioned new projects were Chinese.

However, there is still limited competition between Chinese and non-Chinese firms. The Chinese market is overwhelmingly controlled by domestic firms, while foreign companies only occupy niche areas in the market. By comparison, companies like Vestas or Siemens Gamesa are better established outside of China. They also operate predominantly outside their home markets. In 2018, 96% of Vesta’s installed capacity

13 Lewis, “Green Industrial Policy After Paris”; Nahm, Collaborative Advantage.

14 Lewis et al., “The Development of China’s Wind Power Technology Sector.”

15 Lewis et al.

took place outside of its home country of Denmark. For Siemens Gamesa, the share was 75% when including Germany, Spain, and Denmark as its home countries.¹⁶ Not only do Western manufacturers sell outside of their home markets, but they also rely on a global value chain—unlike Chinese firms.

Active industrial policy alongside cost considerations explains how Western wind turbine manufacturers came to rely on such a globalized value chain. While Chinese localization requirements in the early 2000s may have been some of the most stringent and most successful of their kind, they are far from the only instance of such policies in the wind energy space. Countries that resorted to explicit local content requirements include Brazil, Turkey, and Canada.

Take Vestas, which is still the largest wind turbine manufacturer in the world and has its headquarters in Denmark. The company has multiple factories across the globe, including in China, the United States, Brazil, Mexico, and multiple countries in Europe. But not all production is in-house. For example, in 2020 40% of Vestas blades were produced by three external contractors in China, Brazil, Mexico, Turkey, and India¹⁷. Since a wind turbine can have up to 22 components and 8,000 subcomponents, its production usually relies extensively on globalized supply chains. Unsurprisingly, China is particularly important in the production of certain components and subcomponents, including permanent magnets.

Most analysts suggest that in terms of technology, Chinese firms still trail their European and American competitors.¹⁸ However, even if the quality is lagging, the cost advantage is remarkable: In 2021 turbines sold in China were 40% cheaper than the global average.¹⁹ And while international prices increased after 2020 due to inflationary pressure on commodity prices, the costs of Chinese manufacturers declined even more quickly in early 2022 creating an even greater gap in costs. Recent reporting has sounded the alarm bells on the profitability of European firms which have struggled to keep up with volatility in the market and competition from China.²⁰

Several factors have driven the continued decline in Chinese prices, which may not be replicable in other countries. First, as is now the case in the EV industry and many other areas targeted by Chinese industrial policy, declining government support has led to

16 Yusta and Lacal-Arántegui, “Measuring the Internationalization of the Wind Energy Industry.”

17 Mazzocco, “Chinese Wind Industry Growing Competitive, but Unlikely To Dominate.”

18 According to Lacal-Arántegui, “Globalization in the Wind Energy Industry.” The average generation capacity of Chinese wind turbines is still below international standards but the quality of Chinese products is catching up quickly.

19 “China’s Wind Giants Hatch Plans to Muscle In on U.S., Europe.”

20 Reed, “Europe’s Wind Industry Is Stumbling When It’s Needed Most.”

growing competition. Manufacturers are negotiating lower prices with suppliers to reduce costs to win contracts and make up for the end of government subsidies after 2020. China also benefits from particularly cheap commodities including steel, which makes up 84% of a turbine's weight. The low cost of steel is also the result of government intervention over the years.

This cost advantage plays out in the global market for wind turbine components and is pushing many Western companies to rely more on Chinese production. A 2020 study by the European Union on bottlenecks for European supply chains estimated that 58% of turbines supplied to Europe were produced in the European Union as opposed to 23% in China. However, when it came to components, the shares were almost inverse with 56% of production in China and 20% in the European Union.²¹ China was similarly leading in the production of processed and raw materials including components like permanent magnets made of neodymium, potentially offering further cost benefits to Chinese manufacturers.

Cases of Localization

The most successful cases of supply chain internationalization involving Chinese firms and clean energy technologies have been in the solar photovoltaic industry, especially in Southeast Asia. Most of the production that has been relocated outside of China consists of the latter stages of assembly, although the production of wafers is also growing.²² For now, wafers are still almost exclusively produced in China and any kind of significant diversification of the supply chain will likely take years. The continued importance of Chinese inputs for Southeast Asian production of solar panels has been significant enough that it continues to be an object of attention for U.S. policymakers. Since Chinese-made solar panels are subject to import tariffs and the Uyghur Forced Labor Prevention Act, determining whether Chinese companies are actually producing solar panels in countries like Vietnam and Malaysia or simply using them to skirt sanctions is at the heart of the ongoing trade dispute.²³

Tariffs appear to have been the main driver of the trend so far. Another likely factor is domestic industrial policy in the countries that have received some major investments. It is worth noting that since solar panels are a lightweight, internationally traded commodity with very limited customization, there seems to be no advantage to assembly near the final market.

21 Bobba et al., "Critical Materials for Strategic Technologies and Sectors in the EU - a Foresight Study."

22 Vincent Shaw and Hall, "Chinese PV Industry Brief."

23 Swanson and Plumer, "Chinese Solar Makers Evaded U.S. Tariffs, Investigation Finds."

Trade tariffs, however, are not the only type of driver that can play a role in changing investment patterns and manufacturing decisions. Cost considerations and interest in being closer to the end market seems to be the main factor driving internationalization in the battery industry.

The Rapid Expansion of the CATL

With the expansion of the domestic EV market and manufacturing in China, the country has also become a central node in the supply chain for batteries globally. China is especially dominant in the production of key upstream components like anodes and cathodes.

The Fujian company CATL has become the poster child for China's rapidly growing battery industry; it is now the largest battery manufacturer in the world and is expanding internationally to serve markets in Europe. CATL's expansion in Europe appears to be driven by the demand for its products by European EV makers, who in many cases use the company as a supplier for their vehicles produced in China. Companies that have deals to buy batteries from CATL in Europe include BMW, Mercedes, Volkswagen, and Solaris. In the future, it may be that CATL's presence could facilitate the production of EVs by companies from China as opposed to the other way around.

CATL announced that it started producing battery cells in its new German factory in December 2022, and also in 2022 it revealed it will build a \$7.6 billion plant in Hungary.²⁴ Once completed, the latter would be the largest battery factory in Europe.

24 "CATL's German Plant Receives Approval for Battery Cell Production"; Reuters, "China's CATL to Build \$7.6 Bln Hungary Battery Plant to Supply Mercedes, BMW."

Potential Cases of Localization

Solar photovoltaic firms investing in Southeast Asia and battery-maker CATL are the two most visible examples of Chinese clean energy companies expanding manufacturing outside their home country. So far there are very few other examples. The EV and the battery industry (beyond CATL) are two of the most likely candidates for some diversified production in the medium term. In both cases, European countries and North America will be the most likely recipients of this type of investment.

There are a few reasons why EV and battery companies are considering investing in Europe. First, it is the largest market for EVs outside of China and is growing fast. Second, Europe has a dependable electric grid and a rapidly expanding charging infrastructure. Finally, Europe remains more open to Chinese investment than the United States while offering access to an advanced technological ecosystem that is particularly specialized and competitive in the auto industry. It is possible that rising electricity costs may affect the demand for EVs in Europe in 2023, but, overall expectations are that the market share of EVs and investment in their production is set to rise.

The Overseas Expansion of Chinese EV Manufacturers

Aside from BYD's e-bus empire, Chinese EV manufacturing is thus far largely in the planning stage in Europe. Outside of Europe plans are even less concrete.²⁵ Yet, the topic is politically charged because the automotive industry is a major employer and an important industry in Europe, so if imports from China were to undermine the local industry it could cause tensions.

There are a couple of different mechanisms through which investments happen: acquisition or greenfield investments. In the case of Volvo, the investment has arguably already taken place through acquisition. The now Chinese-owned company is a legacy European brand and has established automotive production plants in Europe and North

25 There have been repeated, and conflicting, announcements of a JAC Motors factory in Brazil since 2017 to produce EVs, but so far, no construction has started. See: Manson, "JAC Motors Plans to Build Electric Car Factory in Goiás"; Liao, "JAC Motors to Set Up Its First Brazil Factory as Nation's Car Sales Exceed Forecasts"; de Oliveira, "JAC pode ter fábrica de veículos elétricos em Goiás." Great Walls Motors (GWM) recently acquired a factory in Brazil where it reportedly aims to make EVs, but production isn't scheduled to start until the second half of 2023 (see "GWM Officially Acquires New Factory and Releases Brazil Strategy."). BYD recently announced it acquired land in Thailand to build a factory there to make EVs, with production reportedly starting in 2024 (see "China's BYD Signs Land Deal to Build First EV Plant in Thailand."). Even more mysteriously, Egyptian automaker El Nasr recently was reported to have closed a deal with an unnamed Chinese automotive company to jointly initiate EV production in the country after more than three years of negotiation with various firms (see "El Nasr Could Sign Final Contracts to Produce EVs next Month.").

America that it is now converting to produce EVs. The firm was bought by Chinese conglomerate Zhejiang Geely Holding, best known as Chinese automaker Geely's parent company in 2010. Volvo produces electric cars in one of its existing plants in Europe and in the United States, and it recently announced plans for an entirely new factory dedicated to EV production in Slovakia.²⁶

Volvo and Geely have established two joint ventures focused on EVs, the most notable being Polestar. The latter is already the most popular Chinese EV brand in Europe, but the vehicles are still made entirely in China.²⁷ Nonetheless, this may be the best candidate for a Chinese brand that will start production in Europe and North America soon given Volvo's established and successful factories in both regions.

The next most notable Chinese-owned European brand in the automotive space is MG, which is owned by SAIC, a Chinese state-owned enterprise since 2005. Although MG's EV models have done very well on the British market, the vehicles are produced in China.²⁸ MG also has factories in India and Thailand that serve the local and regional markets, but they do not appear to make any EV models.

Even though their European market share remains insignificant, the expansion of Chinese start-ups such as NIO and XPeng attracts regular media attention. Neither has announced any plans to produce in Europe, or any other foreign market at the moment.²⁹ Although XPeng is not a useful case study for understanding the growth of Chinese manufacturing in high-value-added industries, its experience in Europe may be instructive as to the advantages of having a nimble production closer to the market. The company reportedly stopped receiving orders for new vehicles in Europe in June due to disruptions in its supply chain in China and at the time of writing had yet to resume sales³⁰. This too may ultimately be a powerful pull factor for companies seeking to expand their international sales.

26 While Volvo's European factories predate Geely's acquisition of the company by several decades, the American plant in South Carolina was first opened in 2015.

27 According to data published by CarSalesBase, a database of car sales, the model Polestar 2 performed the best of all Chinese-owned brands in Europe in 2021 with 20,000 units sold—although not enough to rank in the top 10. It is notable that despite promising sales in Europe and the presence of Volvo factories in Europe, Polestar cars are still produced in China. Polestar is also unique among Chinese EV companies for having already entered the U.S. market. However, only a few units were sold in 2021 reportedly due to disruptions in the supply chain. There have been statements indicating that the company might begin production in South Carolina near an established Volvo factory, but this is likely going to depend on the brand's performance.

28 Holland, "UK Plugin EV Share Grows YoY, BMW Leads In May."

29 NIO, however, has announced the construction of a manufacturing plant in Hungary to build battery swapping stations. Battery swapping, which is not particularly popular outside of China, is a service offered by the company as an alternative to fast-charging stations.

30 Randall, "Xpeng Has Stopped Accepting Orders from Europe."

In short, Chinese manufacturing so far seems to be limited to Volvo, a European company with significant brand recognition that has established factories. Volvo's factories may offer Polestar a cost-effective way of internationalizing production as well. A major variable in whether more companies will decide to invest in production in Europe will undoubtedly be market performance. If sales increase significantly, they will likely have strong incentives and face some pressure to localize production. A separate discussion concerns electric buses and BYD. While the latter is China's leading EV company, its EV passenger vehicle sales overseas are still limited.³¹ However, BYD boasts electric bus manufacturing plants in California, Brazil, and Hungary, in addition to facilities and joint operations in other countries for assembly and maintenance and after-sales services.³² Although the vast majority of BYD's e-bus sales take place in China, where in 2021 it was still estimated to be second to e-bus maker Yutong,³³ the brand is growing rapidly in various markets including Europe and South America.³⁴

Yutong also sells e-buses abroad but has so far not opened any local factories that are specifically dedicated to EVs.³⁵ Notably, Yutong maintains a leading market share and delivers vehicles internationally while maintaining most of its production in China. This suggests that there may also be non-economic reasons for BYD's choice to open regional production plants, including establishing good relationships with governments, which can lead to procurement contracts. Within China, BYD has also distinguished itself by opening multiple factories in various provinces, presumably closer to new markets.

Batteries

While CATL is the most high-profile Chinese battery maker with two factories set to start production soon in Europe, it is far from the only player. Several other Chinese firms have announced plans to open factories in Europe and several have already secured

31 BYD launched its battery-electric SUV model, the BYD Tang, in Norway in 2021. By July 2022 it had sold around 2,000 vehicles (see Demandt, "BYD Tang EV European Auto Sales Figures."). To put that number into context: In 2021 alone, 152,000 plug-in vehicles were sold in Norway, so BYD's market share is insignificant. BYD is reportedly looking to expand its presence in Hungary with a new battery facility to support its launch of passenger EVs in other European markets.

32 In Europe, the company had a factory in France that has since been shuttered due to poor demand.

33 Kane, "There Is One Company That Sells More EV Buses Than BYD."

34 In Europe, some estimate BYD is only second to Polish e-bus maker Solaris (see Kane, "CATL Batteries To Be Used By Europe's Top Electric Bus Maker Solaris."). Thanks to orders of BYD e-buses, Santiago, Chile's capital, became the city with the largest electric bus fleet outside of China in 2019 (see Kane, "Chilean Capital Of Santiago Ordered 183 More BYD EV Buses."). More recently, BYD announced a deal to supply 1,000 buses for Bogotá's bus fleet in Colombia (see "BYD Wins the Largest Pure-Electric Bus Order Outside of China.").

35 The only foreign plant is a joint venture in Port Qasim, Pakistan, which based on information from its website, Yutong Master, appears to mainly assemble internal combustion engine vehicles for the local market. There has been news of a potential second Pakistani plant, but it is too early to tell if that will materialize and what type of vehicles it would produce (see "Chinese Firm to Set up Bus Factory in Sindh.").

funding and local government support.³⁶ For example, SVolt, a GWM spin-off company, has made news for planning two German production plants.³⁷ BYD, the second-largest Chinese battery maker, announced it was looking to build a battery plant in Europe, reportedly to supply passenger vehicles rather than buses.³⁸ The third largest Chinese player, CALB, has also indicated that it's also considering an expansion in Europe.³⁹

Outside of Europe, there has not been any significant expansion of Chinese battery manufacturers aside from BYD's battery assembly plant in California that serves its bus factory. This may change as demand increases in the United States and incentives from the Inflation Reduction Act kick in. CATL was reportedly considering opening a plant in Mexico close enough to the border to supply U.S. companies, but no tangible plans have been announced.⁴⁰ More recently, Ford and CATL announced they were considering a partnership to build batteries in the United States but the plan appears to have met political resistance.⁴¹

Some clear trends emerge from the analysis of Chinese firms operating in the EV and battery spaces. Chinese battery production is likely to expand much faster than that of EVs in Europe because of the rapidly growing demand from European EV manufacturers. This is facilitated by the fact that companies like CATL have established relationships with European EV manufacturers in China. Chinese battery companies are not untested suppliers, but rather ones that are following their clients as they expand internationally.

Moreover, high demand for batteries and proactive government policies are fueling a broader expansion of the sector in Europe. Korean firms like LG and Samsung have already opened factories in Europe. Some automotive companies like Volkswagen and Stellantis are hoping to launch in-house production or partner with existing manufacturers to make batteries for their vehicles. Many more battery production plants are expected to emerge in the coming years in Europe as the demand for EVs continues to grow. Chinese firms are thus following a broader trend rather than breaking new ground by investing in Europe.

36 Ling, "Chinese Battery Makers Are Setting up in Europe."

37 Reuters, "China's SVOLT Picks Same German State as Tesla for Second Battery Cell Plant."

38 Reuters, "China's BYD Hires Engineers for Europe EV Battery Plant"; Polissetty, "BYD Plans for European Battery Plant Make Progress."

39 Randall, "CALB to Build Battery Plant in Europe."

40 Lambert, "Tesla Battery Supplier CATL Is Scouting New Factory Sites in Mexico."

41 Johnson, "Ford Weighs Adding US EV Battery Plant with China's CATL"; Laing and Ludlow, "Youngkin Says Ford Has 'Trojan Horse' Relationship With Chinese Battery Maker."

A Mixed Outlook

EV production is likely to follow a more uneven path compared to the battery industry when it comes to localizing manufacturing. Whether their plans for expansion succeed will ultimately depend on local demand for vehicles and the popularity of Chinese brands. Europe's advanced manufacturing base may in some ways make it a more desirable location compared to locations with less developed industrial bases. Several Chinese automakers, including SAIC and Geely, already have R&D centers throughout Europe. Acquiring access to an advanced R&D ecosystem may similarly explain why NIO recently announced it will be opening its U.S. headquarters in San Jose, California, where it also hopes to open its manufacturing plant to serve the North American market. However, it seems unlikely that the company will be moving forward with such plans before it actually starts selling vehicles in the United States.

There is a real possibility that countries with less advanced industries may miss out on the benefits of the expansion in EV and battery manufacturing. Outside of more technologically advanced regions like Europe and the United States, Chinese EV manufacturing might follow the pattern of multinational automotive companies in the 1990s and into the 2000s where most R&D and advanced manufacturing was performed in the home country while production in China and other emerging markets largely consisted of assembly and lower-end manufacturing. The countries in the most advantageous position may be those that operate within a free-trade arrangement with wealthier markets but benefit from lower costs, like Mexico. Hungary, which is attracting significant investment in the battery industry, including from CATL and Chinese battery-maker EVE, seems to have been a beneficiary of this kind of strategy.

Overall, however, trends suggest that Chinese companies in the EV and battery manufacturing spaces may eventually internationalize some of their production—or at least broadcast their willingness to do so and bring manufacturing jobs to their new markets. Cost structures may have something to do with this, as do considerations about local politics, which in many countries may be turning increasingly wary of Chinese capital. This appears consistent with the experience of non-Chinese automakers over the last century who localized production due to a mix of economic and political factors.

For now, it remains unclear exactly how the Chinese government views this kind of expansion. While the trend does risk reducing China's central role in some value chains, internationalization is a necessary step for Chinese firms to establish themselves as global brands and compete successfully with international companies outside of China itself. Moreover, it seems likely that production in Europe or North America would be connected in some ways to value chains within China.

As the paper will show, the Chinese wind turbine industry's international expansion is developing very differently, with no evidence of manufacturing plans outside of China to accompany an expansion in international sales.

Missing in Action: Widespread Lack of Localization

This paper has so far argued that there are very few examples of Chinese clean energy technology companies that are expanding production outside their home country. However, in some cases, like EVs and batteries there may be potential for growth as the industry expands. In the case of wind turbines, the advantages of production in China seem to outweigh those of producing closer to the end market for now.

Why Does The Wind Not Blow Overseas?

Although Chinese turbine manufacturers' market is still predominantly within China, they are expanding their international footprint rapidly. Yet, while some studies investigate the reasons for Chinese wind turbines' slow internationalization, very little has been written on why there have been no efforts to localize production internationally. As some have noted, Chinese firms have carefully avoided countries with local content requirements because they would lose their cost advantage.⁴² For example, a flurry of new Goldwind contracts in Brazil were announced after wind projects began to qualify for private loans, avoiding the local content requirements that come with financing from the Brazilian development bank, BNDES.⁴³

Goldwind, the largest turbine manufacturer in China and a regular contender for the top slot globally, has been involved in multiple projects internationally even though these still only represent a small fraction of its overall business.⁴⁴ However, there has been no indication that Goldwind has ever considered opening factories in any location close to one of its international projects. Neither has there been any suggestion that it may diversify production to better cater to the growing number of orders from third-party developers, especially in Europe.

42 Laca-Arántegui, "Globalization in the Wind Energy Industry."

43 REVE, "Goldwind Advances in Brazil's Wind Power."

44 In Australia, Goldwind has a local subsidiary, Goldwind Australia, which has been responsible for at least nine completed wind farms, including the 450 MW Clarke Creek project (which has since been sold to an Australian company) and the Moorabool Wind Farm, which the company still owns and has been operating since 2020. Goldwind has also undertaken projects much farther afield, for example in Argentina. The Loma Blanca project (which consists of four distinct phases) is Goldwind's first fully owned wind power project in South America and adds up to about 300 MW of capacity.

Goldwind is also a majority owner of German wind turbine company Vensys, which licenses its technology primarily to Goldwind itself. Envision, another Chinese firm has a research center in the United Kingdom as well, but there is no indication that it intends to engage in local manufacturing.⁴⁵ So, Chinese firms are far from isolated and do seek access to European know-how and R&D through direct investment in the region, but have little interest in the manufacturing component of the value chain.

One reason why investing in manufacturing abroad is less attractive, is that Chinese firms are unlikely to benefit from the same conditions that contribute to low production costs in China. This is especially true for Europe, given the volatility in the prices of energy and steel throughout 2022. China's manufacturing advantage plays out in the upstream segment of the industry since the country is a large producer of components and processed and raw materials.⁴⁶ This cost advantage in some cases also benefits non-Chinese companies. Amongst China's exports of components and turbines, many are orders by Western companies and even products of factories owned by those companies in China. Given their limited access to the Chinese market and the growth in international demand, companies like Vestas have been known to ship parts from China to, for example, the United States to build projects there.⁴⁷

This trend is not unlike what happened in some instances in the EV industry. For example, Tesla vehicles represent a large share of Chinese EV exports to Europe—something which may change as Tesla's production in Germany ramps up and Chinese EV brands gain popularity abroad. It highlights, however, how many multinational corporations under some aspects can benefit from China's industrial policy. While these firms may eventually be squeezed out of the Chinese market as domestic firms lead in sales, they may still benefit from lower costs of production, which can bring an advantage when competing internationally. This at least has been the case so far, although international tensions and incentives to move production to Europe and the United States may change the incentive structure for firms.

45 Ming Yang appears to be the only Chinese turbine manufacturing company that has ever indicated an interest in opening a factory outside of China (see "China's Wind Giants Hatch Plans to Muscle In on U.S., Europe."). The statement was made during a single interview with Bloomberg News, however, and there appear to be no tangible plans in place.

46 Bobba et al., "Critical Materials for Strategic Technologies and Sectors in the EU - a Foresight Study."

47 Interview with senior employee of European wind turbine manufacturer, spring 2021.

Evaluating the Trends

Chinese clean energy companies' internationalization is still in its early stages and case studies are limited. This complicates the analysis of motivations and outcomes, but the trends are still visible enough to reach some conclusions, especially regarding the trajectory in these industries. Overall, there are few cases of Chinese clean energy technology companies locating manufacturing outside the country. In many cases the right incentives still seem to be lacking: Demand is still limited (EVs and wind turbines); there is no clear cost advantage (wind turbines); lack of strong enough draw in the recipient country; or limited demand for customized products (solar panels). When we see investment in manufacturing outside of China, the main drivers appear to be trade tariffs (solar panels) and, in the case of batteries, a combination of cost considerations, demand, and host government incentives. For EVs and batteries it is likely that political considerations, customization, and cost will contribute to an increase in manufacturing outside of China. These do not seem as likely to happen in the wind industry—at least for now.

Battery costs are highly dependent on international commodities like lithium, which means that while there are cost advantages to producing in China, they are less significant compared to those for the wind industry. There is also a clear advantage to being near EV manufacturers, and European governments (including local governments) have provided attractive incentives for manufacturers to invest. This is also a strong pull factor to localizing production in Europe because of the growing demand in the region and the established relationship between Chinese battery manufacturers and EV makers in Germany, most notably CATL and Volkswagen. The expansion of Chinese battery plants in Europe comes at a time of growth for the industry throughout the continent due to the growing demand for EVs and government incentives.

Chinese EV companies have trailed battery manufacturers when it comes to both international sales and international production. However, there are several signs that companies are interested in localizing production or assembly closer to expected growth markets such as Europe, Brazil, and the United States if their sales increase. Here, pull factors include local government incentives and better access to local markets. The main push factor is likely the high levels of competition domestically. There may also be a perceived learning and upgrading opportunity from localizing in areas with a legacy of advanced automotive manufacturing such as Europe and the United States.

A few Chinese automotive groups have acquired European companies over the past few years and operate R&D centers in the United States and Europe, for example. In terms of cost, the companies that are leading the way in foreign markets are proposing their mid-to-high-end models and in some cases solely competing in the luxury segment. They are thus competing directly with higher-end European brands. The expansion of Chinese EVs in lower-income markets like Bangladesh or Indonesia is likely to develop differently and face different incentive structures, which are worth investigating in the future.

Finally, Chinese wind turbine manufacturers appear to be those with the biggest cost advantage in staying within China and the least significant pull factor to internationalizing production. Cutthroat competition within China has led to falling manufacturing costs as well as a push to find new markets. So far, all signs suggest that Chinese firms will continue to export all components for turbines from their home country factories rather than localize any production in local markets. Europe would likely be the most attractive location should firms decide to open manufacturing plants, because companies may perceive there to be a learning opportunity for accessing advanced R&D and technological upgrading. Like in the case of EVs, Chinese companies have already acquired European firms to license new technology more easily or opened R&D centers in Europe. Unlike the case of EVs, European firms are still considered to have a technological edge over their Chinese competitors.⁴⁸ However, so far, no tangible plans have been announced for opening European plants, and recent inflationary trends in Europe will discourage any such investments for the foreseeable future.

The result is that Chinese battery companies have been the most eager to internationalize manufacturing while wind manufacturers have been the least likely to indicate interest in doing so. By comparison, non-Chinese firms in each of the three industries have internationalized production effectively and rely extensively on global supply chains for components.

The implications for the diversification of supply chains outside of China are mixed. Manufacturing outside of China in emerging technologies that benefit from state support within China is indeed possible but may depend significantly on the technology, the market, and cost structures. The latter can be influenced significantly by recipient country policies and incentives. Chinese wind firms have conspicuously avoided contracts in countries with local content requirements for example, but EV and battery makers are likely to benefit from an increase in incentives in Europe. Certainly, BYD's bus factory in California benefitted from its relationship from the city of Los Angeles where it won several large procurement contracts.

48 Laca-Arántegui, "Globalization in the Wind Energy Industry."

Chinese firms are linked to global value chains in multiple ways and the narrow focus on manufacturing does not diminish the importance of those ties and international networks to the development of clean energy technologies in China. One conclusion, however, is that some of those very ties may also drive the patterns of Chinese firms' internationalization and could contribute to the particular interest in European markets and manufacturing.

Conclusion

The trends analyzed in this paper are still under development, but they hold important implications, nonetheless. First, Chinese clean energy technology companies have been relatively quick in expanding their foreign market share but production outside of China is still lagging. Second, it seems clear that there is no one pattern for the internationalization of manufacturing of Chinese firms in clean energy technology sectors. Despite having received comparable levels of government support in China, the decision to open manufacturing plants internationally seems linked to industry-specific costs and incentives (including institutional incentives inside and outside of China).

Third, when companies do choose to localize production, Europe appears to be the preferred destination. This is due to a combination of factors: Demand for clean energy technologies including EVs and batteries is strong in Europe; European countries have generally been more welcoming of Chinese investment compared to the United States; the European Union has been supportive of expanding battery supply chains in Europe; many Chinese EV and wind firms already have R&D centers in Europe. The latter could help companies tap into human capital resources and benefit from regional expertise in advanced manufacturing. Europe's current economic woes and the introduction of incentives linked to local manufacturing requirements in the United States may shift some of this balance. Countries close to important markets such as Mexico and Hungary are likely to be big winners in the automotive and battery segments.

Automation may further exacerbate this trend as low wages are no longer a significant comparative advantage for developing economies seeking to attract manufacturing. Providing financial incentives to attract investment may ultimately be more successful moving forward but may prove to be especially costly for emerging economies. Finally, the research raises the question of how we should understand the global expansion of Chinese manufacturing in clean energy technology—or lack thereof. Overall, the diversification of production would be positive for bolstering the resilience of supply chains and economic development. This is the case even when ownership of

the production plants is Chinese, especially if Chinese firms integrated into global and value chains strengthening local players.

Localization, however, may not always be possible, cost-effective, or in the interest of the company. For example, while Chinese EV manufacturers are aiming to gain market share by enhancing the quality of their products while providing competitive prices, Chinese wind turbine manufacturers have largely competed with Western companies by providing cheaper and sometimes less sophisticated equipment. As a consequence, understanding the circumstances in which companies may be more likely to localize and what types of policies are conducive to this could be beneficial to countries seeking to diversify their supply chains.

More research is also needed to understand how much of the production process will be moved abroad, especially for EVs and batteries. Much research in the past has focused on how industrial policy in China has led to unfair competition internationally, but as Chinese firms internationalize, more thought should be given to ensuring they can also be channels for technology transfer and employment in developing economies and further contribute to global innovation.

Given how established these firms are within China it seems unlikely for now that the Chinese government would act to restrict companies seeking to open manufacturing facilities overseas. It may do so, however, if it fears that Chinese firms may diminish their investments in upgrading manufacturing domestically. After all, the Chinese state poured significant resources into developing and supporting these firms so they could help strengthen the Chinese economy. These companies' international expansion appears for now to be viewed positively in Beijing, but support could change if these firms were to outsource production or water down their contribution to Chinese growth. More research on all these aspects will be important as Chinese companies internationalize further.

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