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**SWEDISH NATIONAL
CHINA CENTRE**



Chinese presence in the Swedish wind energy sector

Vulnerabilities and risks

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Executive summary

- China's dominant role and ambitions in green technology have sparked concerns about current and future economic and political vulnerabilities in Europe. This report examines the vulnerabilities and risks associated with China's presence in Sweden's wind energy sector by mapping Chinese ownership of wind farms, the use of Chinese-made turbines and dependence on Chinese supply chains. Based on this survey, specific risks are identified and assessed, drawing on previous research and expert interviews.
- The report finds that Chinese state-owned companies control 10.4 percent of Sweden's installed wind power capacity, which corresponds to 3.4 percent of total electricity production. While Chinese-made turbines contribute less than 1 percent of installed capacity, the dependence of non-Chinese turbine manufacturers on Chinese supply chains is found to be high. China provides 70–80 percent of many key components globally and undertakes nearly 100 percent of the refining of key rare earth elements.
- The report identifies five key specific risks associated with Chinese ownership and supply chain dependence: potential electricity supply cuts and market manipulation, information transfer, export restrictions, IT sabotage and indirect economic and political influence.
- While Chinese ownership has garnered the most attention in Sweden, the risks associated with this are assessed as relatively low at current levels. The risk of electricity supply cuts and price manipulation is deemed low due to the limited market impact and high costs such actions would incur for Chinese interests.
- Instead, the most significant short- and long-term vulnerability is deemed to be dependence on Chinese supply chains. These could be used to limit the availability of spare parts or components for new turbines and could be employed across a continuum, ranging from subtly skewing competition to complete export bans targeted at individual countries or Europe as a whole.
- Supply chain dependence and long-term European wind industry competitiveness are connected to the broader overarching and long-term risk of Chinese economic dominance. Viewed in isolation, Chinese leadership in wind technology, manufacturing and ownership is probably manageable. However, as an additional sector dominated by Chinese companies, it contributes to the overarching strategic threat to Sweden's and Europe's long-term economic prosperity and political autonomy.
- Policymakers need to strike a balance between the benefits of China's role in the wind energy sector and the risks it poses, both in the short and long term. Several initiatives are under way within the European Union to this end, such as the de-risking initiative and economic security strategy, as well as more specific measures like the Net-Zero Industry Act, the Raw Materials Act, and the Foreign Direct Investment Regulation. If implemented well, these will reduce existing wind sector vulnerabilities.
- In addition to EU initiatives, Sweden could independently implement further policy measures to reduce ownership and supply chain vulnerabilities, such as establishing ownership thresholds or even banning ownership by certain countries, as well as limiting or banning the use of certain turbines and components by implementing non-price criteria in auctions and permits, such as IT security and sustainability standards. Policies could also aim to limit the potential impact of specific risks, for instance by ensuring

clear legal rights for Svenska Kraftnät, the Transmission System Operator, to intervene in the case of antagonistic electricity supply cuts, or by limiting access to sensitive power system information, setting and enforcing high standards for IT security, and enhancing understanding and awareness of potential indirect political and economic influence.

Introduction

China's dominant role and ambitions in green technology have sparked concerns about current and future economic and political vulnerabilities in Europe. China has achieved increasing technological excellence and market share in several technologies essential for the energy transition, including wind and solar power, batteries and electric vehicles. The solar cell industry, with its roots in Europe, is now entirely dominated by Chinese manufacturers. Policymakers in Europe are now worried that the European wind industry could face a similar fate.¹ In her 2023 State of the Union Address, President of the European Commission von der Leyen stated 'We have not forgotten how China's unfair trade practices affected our solar industry' and highlighted the challenges currently facing the European wind industry.²

Such economic concerns, together with a deteriorating global security landscape and colder relations with Beijing, have led to several initiatives at the EU level, such as the Union's broader de-risking policy and economic security strategy.³ For energy technology, the Net-Zero Industry Act proposes further specific goals, including achieving a 40 percent domestic manufacturing capacity by 2030 for strategic net-zero technologies, including wind energy.⁴ To support the recently struggling European wind industry, the EU's Wind Power Package sets out further measures, such as support for the financing of factories and wind farms, as well as trade instruments to ensure a level playing field with non-EU competitors.⁵ In April 2024, the Commission followed up with an investigation into alleged state subsidies to Chinese suppliers of wind turbines to Europe.⁶

Besides China's role in manufacturing and supply chains, Chinese ownership of energy infrastructure in Europe has also raised concerns.⁷ Indeed, concerns about Chinese and other foreign investments across several strategic sectors prompted the EU to establish its screening framework for foreign direct investments in 2019.⁸ In line with this framework, the Foreign Direct Investment Act was enacted in Sweden in December 2023.⁹ The perception of Chinese investment and ownership in Sweden has shifted from initially more positive to increasingly negative.¹⁰ Chinese ownership of large wind farms in northern Sweden has received particular attention in Swedish media and political debates in recent years.¹¹

Even though Chinese ownership and dominance in supply chains are often discussed as potential vulnerabilities and risks in general terms, specific investigations into the nature and magnitude of these risks are less common. This report aims to provide such analysis by conducting a case study of the vulnerabilities and risks associated with China's presence in the Swedish wind energy sector. This is important for prioritization and striking the right balance between security and openness, as well as for providing opportunities for continued exchange with China in the policy initiatives currently in development.

The general aim of this report is to map China's presence in the Swedish wind energy sector and analyse potential economic and political vulnerabilities and resulting risks associated with this presence. This is done by mapping Chinese ownership of wind farms in Sweden,

wind turbines manufactured by Chinese companies and non-Chinese turbine manufacturers' dependencies on Chinese supply chains for components. Based on this survey, the associated vulnerabilities and risks are analysed, and policies on how they can be managed are discussed.

The main specific risks analysed are possible electricity supply cuts and market manipulation, information transfer, export restrictions, IT sabotage and indirect political and economic influence. The analysis is based on public data from Swedish agencies and business organizations, along with additional public sources. The assessment of vulnerabilities and risks draws on previous research and semi-structured interviews with six Swedish sector experts and stakeholders conducted in the spring of 2024.

Sweden serves as a useful case study since it is currently the world leader in per capita wind power deployment and has a relatively high share of Chinese ownership. The report's findings are likely useful and applicable to other countries pursuing wind energy and concerned about Chinese ownership and supply chain dependence. The results and methodology could also be relevant and applicable to other sectors and foreign actors.

Threats, vulnerabilities and risks

This section provides background on and an overview of previous assessments of China as a state threat to Sweden's economic, political and security interests, as well as a description of the report's analytical approach.

Background and previous assessments

A report to the European Parliament states that China has become increasingly authoritarian, nationalistic and closed in the past decade.¹² In its external relations, Beijing has become increasingly assertive and, on some occasions, confrontational, according to the report. Its relations with the United States and the European Union have deteriorated. Since 2019, the EU has referred to China as 'a systemic rival', in addition to an 'economic competitor' and 'cooperation partner'.¹³ Overall, the balance of power in the world is changing, from a unipolar order to a possible bipolar US-China configuration.¹⁴

The EU and its member states are currently developing their stance towards China against this backdrop. A key overarching strategy is the EU's de-risking strategy, which aims to manage economic and technological risk, particularly in strategic sectors, where energy technologies are one of ten highlighted areas.¹⁵ The EU's proposal for an economic security strategy highlights four areas in need of risk assessment: risks to the resilience of supply chains, including energy security; risks to physical and cyber security of critical infrastructure; risks related to technology security and technology leakage; and risks of weaponization of economic dependencies or of economic coercion.¹⁶

In Sweden, government agencies share these concerns. Both the Swedish Security Service (Säpo) and the Military Intelligence and Security Service (MUST) identify China as one of three major state threats to Sweden, alongside Russia and Iran.¹⁷ All three countries engage in illegal intelligence gathering within Sweden, with China showing a particular interest in technologies that could benefit its own industry. Unlike Russia and Iran, China has significant economic relations with Sweden, which could be exploited. According to MUST,

through open or covert threats, or merely by the potential to inflict economic harm, China exerts influence over the Swedish economy, public opinion and, ultimately, political decision making.¹⁸

Säpo points out how China acquires knowledge and technology, in part through legal acquisitions, to establish leadership in areas the state has prioritized, such as green technology. According to the agency, these efforts are part of China's long-term strategy and ambition to become an economic, political and military great power, and to reshape the current West-led, rules-based world order. Consequently, China's acquisition of technology and its economic dominance pose a threat to Sweden's economic security and competitiveness, both in the short and long term.¹⁹

A report by the Swedish Defence Research Agency (FOI) quantifies Chinese investments in Sweden and finds that roughly 60 percent of acquired companies are active in sectors that coincide with those identified as strategic by Beijing as part of its 'Made in China 2025' initiative.²⁰ Another FOI report further analyses the vulnerabilities and geo-economic risks associated with Chinese investments and trade in strategic sectors across the EU, including energy. Identified risks include technology transfer, Chinese market dominance, the establishment of economic 'chokepoints', security concerns related to Chinese ownership of critical infrastructure and Chinese influence over decision-making processes within the EU.²¹ Furthermore, a report by The Royal United Services Institute for Defence and Security Studies (RUSI) examines the risks associated with China's position in new energy supply chains, including various export restrictions, from the perspective of the UK.²² The report evaluates these risks based on whether they could impact the UK alone, a group of countries or the entire market.

SOU 2021:87, the final report underpinning the Swedish Foreign Direct Investment Act, outlines the potential risks associated with investments by foreign actors with antagonistic intent. These include various aspects of limiting the supply of goods and services, as well as the risk of different types of information transfer.²³ Furthermore, Svenska Kraftnät (SvK), the Swedish Transmission System Operator (TSO), outlines antagonistic threats to Sweden's power supply.²⁴ These include cyberattacks, physical damage, information gathering, acquisition of real estate and land, as well as issues related to supply chains and subcontractors.

Analytical approach

To structure the analysis, this report uses a simple framework loosely based on general vulnerability and risk assessment frameworks and earlier applied studies.²⁵ A distinction is made between *threat*, *vulnerability* and *risk*, where risk is further operationalized through *specific risk*, *consequence*, *likelihood* and *risk level*. A *threat* is defined as an entity that can exploit a *vulnerability*, whereas a *vulnerability* is defined as a circumstance or weakness that can be exploited by a threat. A threat can exploit a vulnerability in various ways that pose different kinds of *specific risk*. To assess the magnitude of each specific risk – the *risk level* – the framework relies on the definition of risk as $Risk = Consequence \cdot Likelihood$, where *consequence* is the (negative) impact of the risk materializing and *likelihood* is the probability of the risk materializing (i.e. the consequence and likelihood of a threat exploiting a vulnerability in a specific way). The final assessed risk level is thus dependent on these two underlying components and can be ranked low to high in various combinations of high/low consequence and high/low likelihood.

In this report, the primary threat under consideration is the Chinese state, either directly as an actor with antagonistic intent against Sweden or the EU, or indirectly due to issues related to the Chinese state, such as a potential trade war between the US and China, an invasion of Taiwan or a pandemic. The two main vulnerabilities the report focuses on are Chinese ownership of wind farms and dependence on Chinese wind energy supply chains. These vulnerabilities can be exploited in different ways and pose several types of specific risks. The report focuses on the following ones: electricity supply cuts and market manipulation; information transfer; export restrictions; IT sabotage; and indirect political and economic influence. The magnitudes of these risks are assessed through qualitative analysis of previous research and interviews with sector experts. The assessment and conclusions reflect the author's judgment, not necessarily the consensus of the interviewed experts, although such overlaps are common. The specific risk assessments from low to high should be seen as indicative and contain a significant degree of uncertainty. Figure 1 outlines the framework as applied to the current case for illustrative purposes.

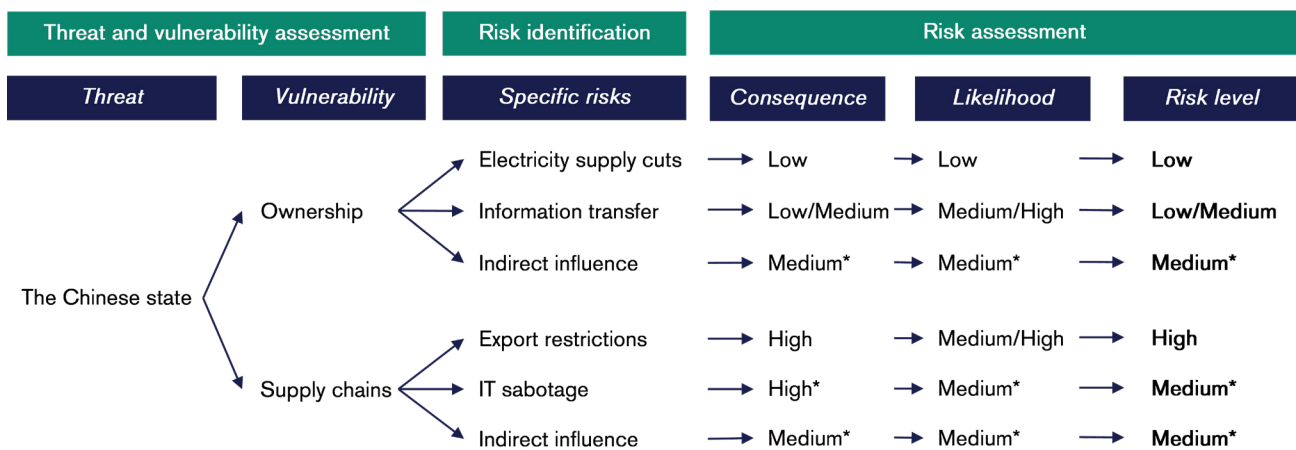


Figure 1. Outline of the analytical framework applied in the report

Alongside vulnerabilities and risks, economic relations with China and access to Chinese technology provide significant opportunities and benefits, such as cost-efficiency, manufacturing speed and scale. These positive aspects are crucial when considering and formulating policy. They are only discussed briefly, however, as the main focus is on vulnerabilities and risk.

Mapping the Chinese presence within the wind energy sector

This section provides a quantitative survey of the Chinese presence in the Swedish wind energy sector in terms of ownership, use of Chinese turbines and dependence on Chinese supply chains.

Chinese ownership of wind farms in Sweden

As of the end of 2023, there were 5 506 wind turbines in Sweden with a combined installed power capacity of 16 251 MW. Together, these turbines produced 21 percent of Sweden's electricity in 2023. Chinese state-owned companies controlled a majority stake in 10.4

percent of this capacity through three different companies (see Table 1 and Figure 2). Two of these companies, CGNEE and Red Rock, are fully owned by Chinese parent companies (CGN and SDIC), while the third, BNR Infrastructure, is a 50:50 joint venture between the Chinese Silk Road Fund and US General Electric. CGN is by far the biggest actor with 8.9 percent of installed capacity. The next section describes the Chinese companies in more detail with a focus on CGN and its corporate strategy. Expected production from the Chinese-owned turbines is equivalent to 3.4 percent of Sweden's total electricity production in 2023.

According to the Swedish Wind Energy Association, no Chinese investors are known to be involved in any wind farms currently under development in Sweden.²⁶ By the end of 2026, with no further acquisitions, the percentage of wind power capacity in Sweden under Chinese ownership is thus projected to fall to 8.5 percent as projects under development come online.

Even though the Chinese share is relatively low, CGN's holdings make it the largest individual wind asset owner in Sweden. Total wind ownership is relatively well diversified among other companies.²⁷ Foreign owners, including Chinese owners, constitute over 60 percent, which is high compared to the foreign ownership of hydropower, nuclear or thermal power.

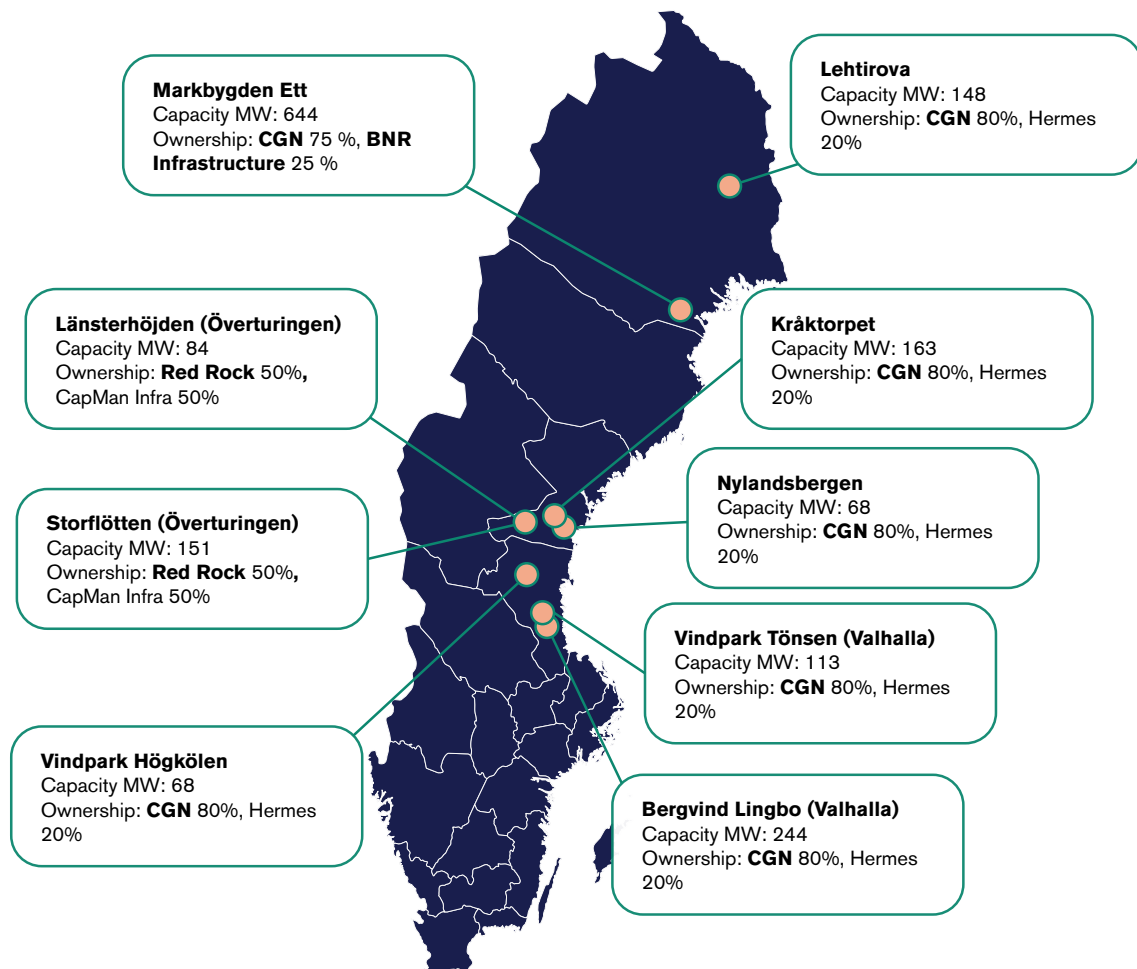


Figure 2. Location of Chinese owned wind farms in Sweden

Notes: Chinese-owned companies are in bold. Source: See Table 1.

The Chinese holdings were all acquired through the acquisition of operating or nearly operational wind farms. The Chinese stakes were obtained in three major transactions. The first occurred in 2018, when CGNEE acquired 75 percent of Markbygden Ett from GE Financial Services and Green Investment Group (Macquarie). In 2020, GE sold its remaining share to BNR Infrastructure. The second series of deals involved CGNEE's acquisition of 80 percent stakes in six wind farms sold by Aquila Capital in 2019. The third transaction was in December 2020, when Red Rock bought 50 percent of two projects from the Green Investment Group (Macquarie).

All Chinese acquisitions occurred before implementation of the Foreign Direct Investment Act on December 1 2023. In addition, all investments have involved other non-Chinese minority owners. Furthermore, each acquisition came with existing long-term Power Purchase Agreements (PPAs) covering the majority of the parks' production, along with the inheritance of long-term service agreements with Swedish developers and western turbine manufacturers.

Table 1. Chinese ownership of Swedish wind farms

Project name	Location	Capacity MW	Production GWh/year	Ownership	Acquisition	Seller
Markbygden Ett	Pitea	644	2150	CGN 75%, BNR Infrastructure 25%	2018 & 2020	Green Investment Group & General Electric
Bergvind Lingbo (Valhalla)	Ockelbo	244	751	CGN 80%, Hermes 20%	2019	Aquila Capital
Vindpark Tönsen (Valhalla)	Bollnäs	113	349	CGN 80%, Hermes 20%	2019	Aquila Capital
Kråktorpet	Sundsvall	163	570	CGN 80%, Hermes 20%	2019	Aquila Capital
Lehtirova	Pajala	148	490	CGN 80%, Hermes 20%	2019	Aquila Capital
Nylandsbergen	Sundsvall	68	250	CGN 80%, Hermes 20%	2019	Aquila Capital
Vindpark Högkölen	Ljusdal	68	250	CGN 80%, Hermes 20%	2019	Aquila Capital
Länsterhöjden (Överturingen)	Ånge	84	278	Red Rock 50%, CapMan Infra 50%	2020	Green Investment Group
Storflötten (Överturingen)	Ånge	151	500	Red Rock 50%, CapMan Infra 50%	2020	Green Investment Group
Total Chinese ownership by share		1325 (8.2%)	4890 (14.2% of wind production, 3.0% of all prod)			
Total Chinese ownership by majority		1684 (10.4%)	5588 (16.2% of wind production, 3.4% of all prod)			

Source: Svensk Vindenergi, Energimyndigheten, FOI²⁸ and other sources²⁹

Notes: Chinese-owned companies are in bold.

Focus: CGN's investments in Sweden – a local example of a global strategy

China General Nuclear Power Corporation (CGN), formerly known as China Guangdong Nuclear Power Corporation, is one of the ten largest Chinese state-owned energy (electricity generating) corporations. It is managed by the State Council through the State-owned Assets Supervision and Administration Commission (SASAC). Its core operation is electricity production from nuclear energy. CGN is China's largest nuclear developer but the company has successfully diversified into wind power and other energy sources both in

China and abroad. The CGN group comprises several companies and subsidiaries, two of which are described below. The group's overarching vision is to 'build a world-class clean energy group with global competitiveness'. According to official statements, it has 'vigorously implemented the "Go Global" Strategy and the Belt and Road Initiative'.³⁰ As of December 2022, the group owned 77 GW of installed capacity, comprising 29 GW of nuclear and 48 GW of 'new' energy.

CGN Energy International Holdings (CGNEI), registered in Hong Kong, is CGN's global platform for overseas non-nuclear energy operations, including development, investment and asset management. According to the company's public statements, CGNEI aims for a global expansion along 'one horizontal and two verticals'. 'One horizontal' describes the company's east-to-west expansion across the Belt and Road countries. The 'two verticals' refers to two north-south expansions through its presence in France and Brazil, 'gradually radiating from Europe to Africa and South America to North America, and forming two "vertical" clean energy development belts'.³¹ As of March 2022, CGNEI had a controlling stake in 13 GW of projects, over 90 percent of which were projects with long-term power purchasing agreements; 2.4 GW of these were wind projects in Europe.

CGN Energy Europe (CGNEE), headquartered in Paris, is CGNEI's division for the European vertical. According to its public strategy, its long-term vision is 'to be one of the major developers and investors in [the] renewable energy market in Europe'. To attain this vision, it has stated the following targets: 'Acquiring new energy assets of 1.5GW by the end of 2018', 'Acquiring the local experiences, obtaining new technologies and taking the European market' and 'Becoming a renewable power provider with the capabilities of self-developing, constructing and O&M'.³² Its key advantage, according to its official statements, is extensive relationships with equipment suppliers in China and strong links with Chinese investors and financing institutions.

CGNEE's wind power investments in Sweden are thus fully in line with the company's official strategy. Its acquisitions constitute a key part of its planned European 'vertical'. CGN's strategy is in turn in line with China's broader strategic economic and geopolitical ambitions and initiatives, such as 'Go global', the Belt and Road Initiative and Made in China 2025. These high-level policies and initiatives provide a foundation for the economic incentives and competitiveness at the company level. For CGNEE, its business decisions are likely economically rational. They are, however, rational in a context of a large-scale government strategy and initiatives. For example, without such a strategy, the risks might be deemed too high or capital would be more expensive for large-scale overseas expansions. There are also likely to be political incentives for companies and individuals to follow national strategies. Still, the success of Chinese companies is to a high degree a result of skill, innovation and economies of scale. In any case, under current conditions, there is probably a strong business case for CGNEE to learn how to operate in the European market, build up its operations and brand recognition, and in the long run develop sites itself, using cheaper Chinese capital and turbines. This expanding market share will further reinforce the Chinese industrial ecosystem and supply chains, while also increasing Chinese ownership of European infrastructure. All this aligns with China's broader grand strategy to increase its economic and political power. Chinese ownership of wind farms in Sweden is thus a reflection of a much larger geopolitical and geo-economic dynamic.

In 2019, the US put CGN on its export blacklist due to allegations that it had stolen US nuclear technology for military use.³³ This indicates how Chinese state-owned companies could be used for information transfer, and also pose an increased risk of becoming entangled in trade disputes.

Other Chinese owners: SDIC and Silk Road Fund

Besides CGN, the two other Chinese state-owned ultimate owners of Swedish wind power are SDIC and the Silk Road Fund. Red Rock Power, headquartered in Scotland, is an owner, developer and operator of renewable energy projects. It is fully owned by SDIC Power, listed in Shanghai, which is the energy arm of China's largest state-owned investment holding company, State Development and Investment Corporation (SDIC). SDIC is managed directly by the central government through SASAC. According to its official statements, 'SDIC Group has always adhered to the national strategy', 'SDIC Group always adheres to the strategy of serving the country' and 'It gives full play to the leading and driving role of state-owned capital in important industries and key fields, and builds itself into a world-class capital investment company'.³⁴

The Silk Road Fund is a state-backed investment fund with the goal of advancing the BRI. It was created by General Secretary Xi Jinping in 2014 and is owned by four financial institutions: the State Administration of Foreign Exchange, the Export Import Bank of China, the China Investment Corporation and the China Development Bank.³⁵

Chinese-made wind turbines

Of the top five wind turbine manufacturers in the world in terms of commissioned capacity, four were Chinese in 2023, with Chinese Goldwind and Envision in first and second place, respectively.³⁶ In 2022, Chinese manufacturers accounted for 66 percent of global orders, while western manufacturers accounted for 22 percent.³⁷ Currently, the vast majority of the Chinese turbines are installed in China, by far the world's largest wind market. However, Chinese turbine makers have recently been growing their share abroad. In 2023, 1700 MW of Chinese-made turbines were installed in 20 different countries, including five EU member states.

In Sweden, the world leader in per capita wind power deployment, no Chinese turbines have been installed since 2016. There are currently only four wind farms with Chinese-made turbines in Sweden: one medium-sized and three relatively small (Table 2). These turbines only constitute 0.9 percent of the total installed wind capacity and a negligible share of total electricity production. There are no wind farms under development with Chinese turbines according to compilations by the Swedish Wind Energy Association.³⁸ However, the final decision on turbine model can be changed during the development and application process. According to one industry expert interviewed, most European developers are currently being courted by Chinese turbine manufacturers, which offer turbines that are 20–25 percent cheaper than western competitors. Similarly, according to the energy consultancy BNEF, prices for Chinese-made wind turbines delivered outside mainland China are 20 percent lower than those offered by European or US manufacturers.³⁹

According to the expert interviews, the reliability of the installed Chinese turbines has been lower than expected. There have been technical issues as well as poor service provision. The climate in Sweden is challenging for turbines, with snow and ice for a large part of the year.

So far, Chinese turbines have been more common in southern Europe, which has a more favourable climate. Differences in electricity markets in northern and southern Europe might also play a role. Wind power developers in Sweden face lower electricity prices and lower subsidies compared to southern Europe, which places a premium on production reliability over low installation cost. These technical experiences and market aspects are likely the main reasons why Chinese turbines are uncommon in Sweden, rather than political or security considerations. As a case in point, one wind power developer interviewed stated that they would consider buying Chinese turbines in the future if they proved reliable in Swedish conditions.

Table 2. Wind farms in Sweden with Chinese-made turbines

Project name	MW	Start year	Turbine manufacturer	Location
Blaiken 3&4	98	2016	Dongfang	Storuman
Tjurhöjden	6	2012	Sinovel	Karlstad
Mortorp	18	2014	Sinovel	Kalmar
Kvilla	18	2014	Sinovel	Torsås

Source: Svensk Vindenergi, Energimyndigheten.

Dependence on Chinese supply chains

European and US manufacturers supply the vast majority of the wind turbines used in Sweden. Vestas, Siemens-Gamesa, General Electric, Enercon and Nordex are responsible for 96 percent of installed capacity. However, while almost all of these turbines are assembled in factories in Europe, they rely to a high degree on Chinese components and materials. Measuring exact dependencies from open sources is difficult, but China's global market share in different segments can provide some guidance.⁴⁰

As of 2023, China accounted for 60 percent of global wind turbine manufacturing capacity, according to the Global Wind Energy Council (GWEC).⁴¹ In terms of manufacturing capacity of key components, China accounted for 80 percent of gearboxes, 73 percent of generators, 82 percent of converters and 82 percent of castings. In addition, it accounted for 60 percent of the global blade capacity and over 70 percent of towers.

Rare earth permanent magnets used in generators are heavily reliant on Chinese supply chains. As of Q4 2022, China accounted for 68 percent of rare earth mining and 94 percent of processing.⁴²

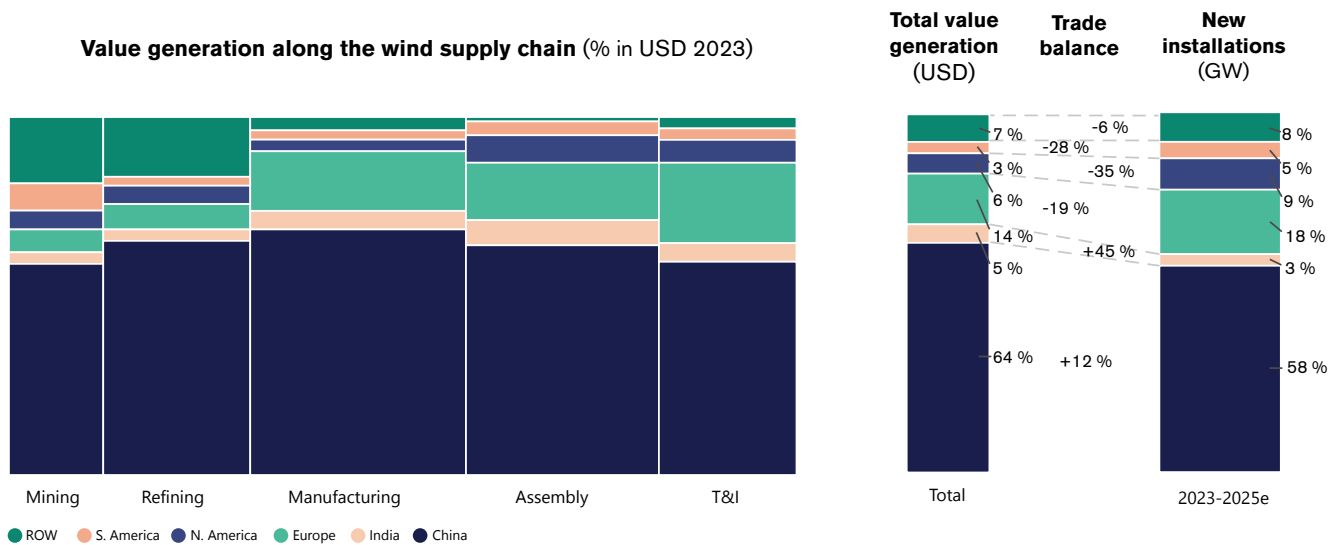
Overall, China generated 64 percent of the total value across global wind supply chains, from mining to transport and installation (see Figure 3). However, it is also responsible for 58 percent of all expected installations. Thus, even though China is a net exporter across the value chain, most of its capacity is currently for the domestic market, which is the world's largest.

Europe is currently self-sufficient for blades and nacelles – the unit on top of the tower that houses the generator, gearbox and drive train – at around 25 GW annual capacity for blades (around 15 percent of global capacity) and 28 GW for nacelles (17 percent of global capacity).⁴³ However, it is likely that a high proportion of underlying nacelle parts have to

be imported from China, given the supply chain figures discussed above. According to one expert interviewed with first-hand knowledge of the origins of the constituent parts of a major European turbine manufacturer, almost all were Chinese-made. The same source pointed out that another, more expensive, European manufacturer used mostly domestic European parts.

For the EU to reach its 2030 RePowerEU wind target, an annual deployment of 28.5 GW is needed. GWEC expects the current self-sufficiency in nacelles to become insufficient from 2026.⁴⁴

Figure 3. Supply chain value generation and installations by location and implied trade balances



Notes: The first five bars show the share of value generation across different segments of the global wind value chain by location, while the sixth bar shows the share of total value generation of all segments. The bar to the far right shows the share of expected installations by location in the coming years. The numbers between the two bars show the trade balance of different locations formulated as degree of wind industry value creation versus installations.

Source: Adapted from GWEC Global Wind Report 2024,⁴⁵ with permission from GWEC and the BCG.

Risks related to Chinese ownership

This section identifies and assesses specific risks associated with the Chinese ownership of wind farms as quantitatively surveyed above. Each specific risk is qualitatively assessed as low, medium or high.

Electricity supply cuts and market manipulation

As owners, companies could choose not to produce electricity from their power plants or to only offer to sell electricity at a certain price. In theory, a large ownership share among Chinese entities (or by any actor) could constitute a risk of antagonistic cuts to the electricity supply or manipulation of electricity prices. Supply cuts, often described as 'the energy weapon' in the energy security literature, have historically concerned fossil fuels and interstate

trade, with Russia's repeated use of gas export cuts as the prime example.⁴⁶ A fundamental difference in the case of a supply cut from domestic power plants by an antagonistic owner is that the assets are located on the territory of the targeted country and could ultimately be confiscated. However, at times of low-level conflict where property rights and laws are followed, an antagonistic owner could in theory carry out such measures legally. The motive behind a supply cut could be to economically harm the targeted country or to exert political influence. Like any economic dependency or 'weapon', it does not need to be actively used to be effective; the mere existence of a vulnerability or the threat of its use could exert political pressure.

In practice, however, there are three main reasons why the risk of supply cuts from Chinese-owned wind power in Sweden can be deemed relatively low, at least for now. First, current Chinese ownership, at 10.4 percent of wind capacity, accounted for just 3.4 percent of total electricity production in Sweden in 2023. This share is too small to have a significant price impact on the market. Furthermore, since wind power is naturally intermittent, grids are designed to handle individual farms occasionally producing zero percent of capacity, so there is a low risk that a supply cut could cause major grid instability or blackouts.

Second, all Chinese wind assets came with long-term Power Purchasing Agreements (PPAs) at their acquisition. The Chinese companies are legally bound to deliver electricity to their counterparts according to their contracted volumes and prices. If the producer does not deliver according to the contract, the accumulating debts could in the end be a legal cause for liquidation and redistribution of the physical assets. This is described further in the Focus section below. In addition, the minority owners present in all Chinese investments would also be likely to protest against any non-economically motivated supply cuts, even though they would have only limited means to alter the company's decisions.

Third, there are also circumstances under which SvK, the Swedish TSO, can legally intervene and command producers to increase production to avoid electricity scarcity and maintain system stability. This is also further described in the Focus section.

Currently, it is therefore unlikely that China would attempt to use its ownership of wind farms as an energy weapon through extensive electricity supply cuts. At current levels of ownership, a shutdown would be unlikely to affect system stability and the long-term impact on prices would be small. Meanwhile, the cost to Chinese companies would be significant, both in terms of debt linked to current PPAs and loss of credibility and future market opportunities in Europe. Consequently, China could likely employ this type of 'energy weapon' effectively only once. Furthermore, wind turbines that are stationary for long periods degrade due to issues such as uneven stress and lubrication deprivation, further increasing the cost of such actions. Finally, as a last resort, SvK could legally intervene if shutting down wind farms were to cause grid instability or electricity scarcity.

The current risk of supply cuts and market manipulation is therefore assessed as low, in terms of both likelihood and potential consequences. That said, it is important to continue to monitor Chinese and foreign ownership, especially in new greenfield investments where Chinese companies might be involved in the development phase and where production is not covered by PPAs. If China were to use its ownership as a weapon, it could also be employed in subtler ways that allow plausible deniability. For example, shutting down a wind farm for alleged 'repairs', a transmission break, a software malfunction or a similar explanation. Such a scenario would be more challenging, or at least time-consuming, for the

authorities to address. Nonetheless, the impact would still be manageable for the reasons discussed above.

Focus: If a producer cuts the power, what does the law say?

Electricity producers' obligation to generate electricity is based on contracts with customers and is therefore not a public law requirement but a civil law commitment.⁴⁷ Producers with no customer contract that sell their electricity directly on the spot market can therefore choose not to produce any electricity, or only to produce at a certain price. However, if the producer has committed its production through, for example, a Power Purchasing Agreement, which is the case with the Chinese-owned wind farms, the producer has an obligation to deliver electricity to its counterpart. Failure to meet this obligation is likely to result in legal action and damages, ultimately risking bankruptcy for the producer and the redistribution of its assets. Such a process is currently underway in Sweden, where CGNEE's Markbygden Ett AB has filed for reconstruction and is seeking to renegotiate its loss-making baseload PPA with Norsk Hydro. If renegotiation fails, the holding company Markbygden Ett AB is likely to face bankruptcy unless additional capital is injected. The financial issues at Markbygden stem from the design of the PPA in relation to market developments and production performance. Due to significantly lower than expected production levels,⁴⁸ and higher and more volatile than expected electricity prices, the PPA has caused substantial losses. When the park's production falls below contracted volumes, CGNEE is forced to purchase often more expensive electricity on the spot market to meet its PPA obligations. Meanwhile, the counterpart of the PPA, Norsk Hydro, profits from the fixed contracted volumes and prices, which are lower than the spot market prices. Since February 2023, CGNEE has failed to deliver the full contracted volumes, leading Norsk Hydro to file claims for compensation.⁴⁹

In addition to civil law commitments, SvK has the right to intervene in certain circumstances. In situations of electricity scarcity even without declared 'heightened readiness' (*höjd beredskap*), SvK has the authority to command producers to generate electricity in return for market-based compensation. This right is also extended to any other event that risks system instability (8 kap. 2 § Ellag 1997:857).⁵⁰ Furthermore, in the event of heightened readiness, war or a special government decision, SvK has been granted a mandate to plan, lead and coordinate the resources of the electricity supply to fulfil society's need for electric power in collaboration with other total defence authorities.⁵¹

Information transfer

According to the experts interviewed, power plant owners in Sweden have access to some sensitive non-public information. This includes details from SvK on how to conduct island operations (manage an independent section of the grid) or a black start (the procedure for restarting the grid from scratch after a total or partial blackout). Owners may also have access to RAKEL-phones, which are part of the Swedish national digital communication system used by the emergency services and other critical sectors. How this information could be used by an antagonistic actor is difficult to assess due to its non-public nature and the partly unknown capabilities of the actor. Beyond this, the experts did not identify any sensitive non-public data accessible to foreign owners that might pose significant security vulnerabilities or that could not be easily acquired through other means.

In terms of information transfer of commercial technology, the risk is probably low. This might have been a concern previously but, according to the interviewed experts, any technological edge previously possessed by Europe has probably already been surpassed by China.

What could be acquired, and is likely to have been one of the motivations for the acquisitions, is information on the management and operations of major wind farms in Europe. Such commercial know-how could strengthen the competitiveness of Chinese energy companies in their efforts to 'go global'. In the longer term, this poses a risk to European wind power industry competitiveness, which could in turn have long-term security implications. In the short term, however, the primary risk is economic, mainly as intensified competition.

Overall, the current risk of information transfer to China due to Chinese wind ownership in Sweden is assessed as low to medium. While the likelihood of various information transfers is deemed medium to high, the consequences are considered low to medium, where the higher range reflects the uncertainty regarding uses of non-public information about the electricity system.

Indirect influence

As with any major investment or economic relation, there is a risk of various types of indirect economic or political influence. For example, Swedish economic and political actors might alter their behaviour to attract foreign investments or avoid harming existing business relationships. The fact that China is a major economic actor and the economic relationship with Sweden is highly asymmetrical exacerbates this risk, as security through interdependence is low, particularly when viewing Sweden in isolation from the EU.

This issue is not unique to wind power investment. Rather, wind investments should likely be viewed in the context of overall Chinese investments and economic relations with Sweden. Consequently, there may be reasons to limit wind power investments as a means of reducing overall exposure to China.

However, the current ownership of wind farms, although significant in terms of capital investment, might provide less potential for influence than other sectors, such as the automotive industry, where China has its largest presence in Sweden through Geely's ownership of Volvo Cars.⁵² In contrast, wind farms are capital-intensive but do not provide many local jobs. More importantly, the operations cannot be moved abroad.

Assessing potential influence, in terms of both occurrence and impact, is challenging. According to a recent report, China exerts real albeit limited harmful influence on democracy in Swedish municipalities, with several examples cited, including threats against local political actors.⁵³ For example, a former Chinese ambassador expressed that a terminated sister city partnership between Gothenburg (where Volvo has its main presence) and Shanghai would undoubtedly have consequences.⁵⁴ Other instances of economic influence include organized boycotts, such as against the Swedish fashion retailer H&M, which was triggered by accusations of forced labour in Xinjiang.⁵⁵ It is reasonable to assume that the risks of self-censorship or other types of political and economic influence increase as economic ties increase. The risk of indirect political or economic influence from Chinese ownership of wind farms is therefore assessed as medium but with high uncertainty, in terms of both likelihood and consequences, reflecting the difficulties in assessing these risks.

Benefits of foreign and Chinese ownership

While this report focuses on risks and vulnerabilities, there are, of course, substantial benefits associated with foreign and Chinese ownership. It is unlikely that Sweden would have seen such a rapid build-out of wind power without allowing foreign capital and investors. Most long-term investors in wind parks are infrastructure funds or pension funds with a low-risk, low-return profile. In Sweden, pension funds have, until recently, effectively not been allowed to invest in wind farms due to demands for higher returns.⁵⁶ Since China's investments have not been in greenfield investments but acquisitions, it is fair to point out that the build-out would have been possible without Chinese ownership. However, the Chinese presence and interest in long-term holdings might affect the decisions of developers with a short-term holding profile.

Chinese state-owned companies have access to cheap capital through various means, such as through its sovereign wealth funds and state-owned banks, especially for investments that are deemed strategic.⁵⁷ Chinese companies can therefore offer a higher price for wind assets compared to private competitors. In summary, access to cheaper capital has helped the build-out of wind power in Sweden, which increases renewable electricity supply and lowers electricity prices.

Supply chain risks

This section identifies and assesses specific risks stemming from the dependencies on Chinese supply chains as quantitatively surveyed above. Each risk is qualitatively assessed as low, medium or high.

Export restrictions

European dependence on Chinese-dominated wind power supply chains constitutes a major vulnerability. Even though the number of Chinese turbines in Sweden is currently low, the dependence of western manufacturers' turbines on Chinese components and materials is high. This dependence comprises different types of risk. Export restrictions could limit access to spare parts for installed turbines as well as reduce the availability of parts and materials for the construction of new turbines by non-Chinese manufacturers.

Export limitations could arise for several reasons, such as non-political supply chain bottlenecks (as was the case following the Covid pandemic) or as antagonistic measures seeking to harm the European economy more broadly or specifically target the competitiveness of European turbine manufacturers. The latter could increase the competitiveness of Chinese manufacturers and the market share of Chinese turbines, further increasing China's control of the global wind power industry.

The risk of export restrictions is assessed as high, primarily because the consequences are deemed high, while the likelihood is deemed medium to high. The likelihood of a complete export restriction is considered low but non-political supply bottlenecks as well as measures to skew competition are deemed medium to high.

Where ownership could be used as a tool towards Sweden in isolation, weaponizing control of global supply chains is a less precise tool. As long as other countries are willing to trade with Sweden, isolated bans could probably be circumvented, although this would come with

additional costs. On the other hand, Sweden could become collateral damage in conflicts or policies aimed at other nations. For example, a US-China trade war could trigger a general export limitation by China, increasing prices for everyone, assuming that non-Chinese countries continue to trade freely with each other.

The use of supply chains as an economic foreign policy tool can thus be employed across a continuum, ranging from subtly skewing competition to directly targeting individual countries, Europe or the West as a whole.

IT sabotage

Cyberattacks targeted at energy systems could result in significant damage.⁵⁸ Today, grids and power plants are highly interconnected, with many power plants operated remotely, increasing their vulnerability to cyberattacks. Wind turbines could, for example, be shut down remotely. In a worst-case scenario, malicious code could alter the turbine's steering, leaving it susceptible to permanent damage, for example, in a storm. Chinese-made turbines, or turbines containing Chinese parts, might be more vulnerable to IT sabotage by Chinese actors due to their knowledge of the system design or potential deliberate vulnerabilities. Moreover, other malicious actors might be able to exploit these weaknesses for various purposes, not least commercially motivated ransomware attacks. China's close relations with Russia also pose a heightened potential risk since many of the world's cyberattacks originate from Russia.⁵⁹ Finally, diversification of components and systems is one way to mitigate vulnerabilities to IT attacks. Overreliance on Chinese components therefore presents an additional risk due to the monoculture it introduces.

The magnitude of the IT sabotage risk is difficult to assess but is deemed medium, with a high level of uncertainty in terms of both consequences and likelihood. This assessment is based on the higher potential for sabotage associated with Chinese components compared to those from other suppliers, as all turbines and components face a substantial risk of IT sabotage. The likelihood of Chinese authorities using these vulnerabilities to inflict physical damage is low in the current conflict setting. However, the risk of other actors, such as cybercriminal groups or state-linked groups in Russia, exploiting vulnerabilities is probably higher.

Indirect influence

Chinese dominance in wind supply chains could also have indirect latent effects. The threat, or the mere possibility of their use, for example by export restrictions, could exert economic and political influence. In addition, similar effects and dynamics associated with ownership and investments apply to supply chain dependence, where lucrative business relationships could lead to self-censorship or influence the decisions of Swedish economic and political decision makers. Like the indirect influence that could arise from ownership, influence through supply chain dependence is difficult to assess, and the risk is similarly deemed to be at a medium level but with a high degree of uncertainty.

Benefits of Chinese supply chains

The key benefits of relying on Chinese supply chains are price and scale. European climate targets require a rapid and large-scale buildout of fossil-free energy production. Furthermore, a competitive economy and industry, as well as public support, demand low

energy prices, which requires cheap energy supply. There are therefore strong economic and political incentives for prioritizing lower costs today over long-term domestic industry competitiveness and security.

Summary of risk assessments

Table 3 summarizes the assessed risks associated with Chinese ownership of wind farms in Sweden, as well as the risks related to dependence on Chinese wind energy supply chains. The assessments are the authors' qualitative evaluations. They should be considered indicative and linked to a significant degree of uncertainty.

Table 3. Summary of risk assessments

Risks related to Chinese ownership	Consequence	Likelihood	Risk level
Electricity supply cuts and market manipulation	<i>Low</i>	<i>Low</i>	<i>Low</i>
Information transfer	<i>Low/Medium</i>	<i>Medium/High</i>	<i>Low/Medium</i>
Indirect influence	<i>Medium*</i>	<i>Medium*</i>	<i>Medium*</i>
Risks related to Chinese supply Chains			
Export restrictions	<i>High</i>	<i>Medium/High</i>	<i>High</i>
IT-sabotage	<i>High</i>	<i>Medium*</i>	<i>Medium*</i>
Indirect influence	<i>Medium*</i>	<i>Medium*</i>	<i>Medium*</i>

Notes: 'Risk level' describes the assessed overall magnitude of the risk, as a function of its two components: 'Consequence', which describes the impact of the risk materializing, and 'Likelihood', which describes the probability of the risk materializing. *denotes assessments with a particularly high degree of uncertainty.

Conclusions

Chinese presence and associated risks

The Chinese ownership presence in the Swedish wind energy sector is noteworthy but still limited; it corresponds to 10.4 percent of installed wind capacity and 3.4 percent of total electricity generation. The number of Chinese-made turbines in Sweden is currently very low, at below 1 percent of installed wind capacity. However, installed turbines made by western manufacturers rely on Chinese supply chains to a high degree. The exact level of dependence is difficult to assess but global figures and European manufacturers' net imports indicate a significant dependency.

Current Chinese ownership and supply chain dependencies constitute vulnerabilities that pose several specific risks of different magnitudes. This report assesses these as follows:

- **The risk of current ownership being used to cause electricity supply cuts and manipulate prices exists but is likely low**, in terms of both probability and consequences. The effect would be limited and the cost would be high for Chinese interests.

- **The risk of harmful information transfer due to Chinese ownership is more uncertain and assessed as low to medium**, where the consequences are assessed as lower and the likelihood as higher. Some sensitive non-public information on grid operations could be acquired but in terms of wind technology, China has likely already acquired knowledge of most of what constituted Europe's technological edge. With regard to business information and market intelligence, however, ownership and operation of Swedish and European wind farms could provide valuable experience for the continued expansion of these companies.
- **Dependence on Chinese supply chains presents high immediate and long-term economic and political risks.** The dependence of European manufacturers on Chinese materials and key components poses an immediate risk. The risk of export restrictions on spare parts or components and materials for new turbines is assessed as high since the negative consequences would be significant for the European wind industry and the EU's energy transition. The likelihood of this risk materializing as a complete export restriction is lower, but the risk of supply chain dominance being used in subtler ways to skew competition in China's favour is likely higher and poses a significant long-term risk. This could lead to Chinese turbines outcompeting western models in the European market. Without policy interventions, the lower cost of Chinese turbines will likely lead European developers to increasingly choose Chinese models going forward.
- **The risk of IT sabotage due to reliance on Chinese components is assessed at a medium level**, but with a high degree of uncertainty. This risk reflects the increased potential for sabotage with Chinese components compared to the components of other suppliers, as all turbines and components are exposed to risks of IT sabotage. The risk that the Chinese state might exploit these vulnerabilities to cause physical damage is deemed low and is only expected to occur in a high-conflict scenario. However, any increased vulnerability increases the risk of, for example, ransomware attacks by other parties.
- **Both ownership and supply chain dependence pose risks of indirect influence on economic and political decision making in Sweden.** The risk level is assessed as medium but with a high degree of uncertainty for both vulnerabilities, reflecting the difficulties in assessing this type of impact and occurrence. There are reasons to believe that the potential impact of wind power ownership is lower than in other sectors due to the low labour intensity of the sector. In any case, the risk of indirect influence from wind power is likely best assessed in conjunction with influence linked to overall Chinese ownership and supply chain dependencies across all sectors.

A broader long-term risk: Chinese economic dominance

The Chinese presence in Sweden's wind energy sector can be seen and understood as a company- and sector-level manifestation of China's broader, high-level economic and political strategy. This strategy, similar to those of most other states, aims to secure China's long-term prosperity, security and power across economic, political and military dimensions. Achieving economic prosperity and power is central to this strategy. What sets China apart from many other countries is the tools and capacities it is able and willing to use to achieve its objectives. Moreover, implementation of China's long-term strategic goals often clashes with the values and goals of liberal democracies. Herein lies the broader threat posed by China's power expansion to many countries, especially to small, democratic and open economies.

In the economic sphere, through various initiatives such as Made in China 2025 and the Belt and Road Initiative, China is encouraging its companies to achieve technological and market leadership in crucial sectors and to 'go global' to expand their markets. Access to cheap capital and subsidies, as well as control over large state-owned enterprises and research institutions can quickly transform global markets.

Becoming a world leader in green technology is one of China's key strategic objectives. Chinese companies have already attained leadership positions in solar power, batteries and electric vehicles, and are rapidly advancing towards dominance in wind energy as well.

In summary, the primary risk posed by the Chinese presence in and expansion into the Swedish and European energy markets is not immediate, but associated with the long-term strategic threat of increased Chinese economic, political and military power. Viewed in isolation, Chinese leadership in wind power technology and ownership is likely manageable. However, as an additional sector dominated and influenced by Chinese companies, it contributes to the overarching strategic threat to Sweden's and Europe's long-term economic prosperity and political autonomy. The specific risks associated with the current Chinese presence should therefore also be assessed based on how they relate and contribute to the long-term threat of Chinese economic dominance.

Policy options

Swedish and European policymakers need to strike a balance between the benefits of China's role in the wind energy sector and the risks it poses, in both the short and long term. So far, Chinese capital has facilitated the expansion of wind power in Sweden. Its supply chains have made European turbines more affordable and allowed the industry to scale-up production more rapidly. This has assisted Sweden and Europe with achieving their energy transition targets. However, left to itself, the European wind industry risks meeting the same fate as its solar industry, placing Sweden and Europe in an unfavourable strategic position in the future, both economically and politically. Ownership and supply chain dependence in each individual project, country or sector might not pose a significant risk in isolation, but the cumulative effect of these dependencies and potential vulnerabilities across sectors could pose a fundamental risk to long-term European competitiveness and political sovereignty. Therefore, a comprehensive, big-picture approach is necessary, where wind energy policy forms one component of a broader strategy on Chinese economic dominance.

The EU's de-risking initiative and economic security strategy provide such an approach. Policy proposals range from ensuring fair competition on a level playing field to setting targets for the share of domestic production. The Net-Zero Industry Act proposes a 40 percent domestic manufacturing capacity for net-zero technologies in the period to 2030, which is probably a good balance. In the case of wind energy, it is crucial that a critical mass of domestic industry remains so that, in the event of an economic conflict or a worsening of relations, the industry can relatively quickly scale-up and re-shore production. Similarly, the Critical Raw Materials Act partly mitigates the material vulnerabilities of the wind power sector and other industries through domestic extraction and processing capacity, recycling and import diversification. Finally, the EU's Foreign Direct Investment Regulation, implemented in Sweden in December 2023, provides an extensive framework and tools for managing ownership issues. In summary, if the EU initiatives currently being discussed are

implemented, they will address many of the current concerns related to China's role in the wind energy sector in Sweden and Europe.

Besides existing EU initiatives, Sweden could also independently implement policy measures to decrease existing ownership and supply chain vulnerabilities, including:

- Pre-emptively establishing a threshold for acceptable levels of non-European ownership, or by countries that might pose a long-term security threat, or even considering banning investment from such countries altogether in strategic sectors such as electricity production and distribution.
- Implementing non-price criteria in auctions and permits, such as cybersecurity concerns and sustainability criteria, as proposed in the wind energy package. Aptly designed, this could increase the demand for European turbines and components.

In addition to limiting the extent of existing vulnerabilities, policies could also aim to limit the potential impact of specific risks, including:

- Ensuring that the Transmission System Operator, SvK, has a clear legal right to intervene in the case of antagonistic electricity supply cuts by power production owners.
- Limiting access to non-essential sensitive power system information, particularly for foreign companies.
- Setting and enforcing high standards for IT security in power systems.
- Enhancing understanding and awareness of potential indirect economic and political influence through further research and information campaigns.

Finally, while Sweden and Europe can control the extent of vulnerabilities, such as foreign ownership and supply chain dependence, as well as many mitigation options for specific risks, they cannot control the intentions of potential threats or their propensity, or likelihood, to exploit existing vulnerabilities. Therefore, continuous monitoring and adaptation to evolving relations with China will be necessary, including reappraisal and rebalancing of the risks and benefits discussed above.



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About the Swedish National China Centre

The Swedish National China Centre was established in 2021 as an independent unit at the Swedish Institute of International Affairs (UI). The Centre conducts policy-relevant research and aims to contribute to a long-term improvement in the state of China-related knowledge in Sweden. Any views expressed in this publication are those of the author. They should not be interpreted as reflecting the views of the Swedish National China Centre or UI.

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