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Europe's Green Technology Development: Chinese Challenges to Research and Innovation Security

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As Europe pursues its ambitious Green Deal objectives, the continent faces complex challenges in balancing open scientific collaboration with the need to protect strategic green technologies and intellectual property. This issue brief investigates the evolving dynamics between European green development initiatives and emerging research security concerns related to China's growing technological influence. The analysis examines Europe's vulnerability in critical green technology supply chains, the implications of China's targeted research investments, and emerging policy frameworks to screen foreign investments while maintaining innovation competitiveness. Through case studies and data analysis spanning 2020-mid-2025, this research provides comprehensive insights into the interplay between technological advancement, security considerations, and international collaboration in the green technology sector.

The European Union's (EU) commitment to becoming the first climate-neutral continent by 2050 has catalyzed unprecedented investment in green technologies and sustainable innovation within the EU. This ambitious agenda has unfolded against a backdrop of increasing global competition for technological independence, particularly from China, which dominates key industries within the green technology vertical. The intersection of climate objectives and technological development has created a complex landscape where cooperation and competition coexist. The Russian invasion of Ukraine has also complicated the green agenda and much focus has been put on the Russian threat to the existential security of Europe, rather than the green transition.

Since the launch of the European Green Deal (EGD) in 2019, the relationship between European and Chinese interests in green technology has become increasingly nuanced

but nevertheless very complex. While China remains an essential partner in global climate action, its aggressive pursuit of technological leadership through initiatives like Made in China 2025 and the Belt and Road Initiative (BRI) has raised significant concerns about European technological sovereignty and research security.[1] These issues have been amplified by the strategic importance of green technologies in achieving climate objectives and maintaining economic competitiveness. There is a concern that the energy dependency on Russia could be exchanged for a dependency on green technology controlled by China.

The challenge with Chinese involvement in research and innovation in the green technology field is not that they are Chinese, but that the Chinese Communist Party (CCP) has weaponized research and innovation, and that the CCP is involved in all aspects of science and innovation in a way that threatens Europe's national security. Chinese researchers are and will continue to be a welcome asset in the European science community as long as they play by the same rules and regulations as Europeans and refrain from involving or manipulating the Party and its tentacles, such as the United Front (统一战线), through pressure and Chinese legislation.

Current State of European Green Technology

Since the adoption of the EGD back in 2019, European green technology development has seen steady progress as a result of addressing the environmental crises from a "whole economy" perspective. As per the report by the Swedish Environment Institute (SEI), more than 150 policies have been introduced as a result of the EDG in key sectors such as energy, industry, transport, and food—and as per January 2025, 168 initiatives have been proposed by the commission under the EGD, 98 of which have been adopted.[2]

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European green technology development has made significant strides across multiple sectors, including renewable energy, sustainable transportation, and energy storage systems. The continent has established itself as a leader in wind energy technology, with particular expertise in offshore wind installations. European firms have also developed significant capabilities in advanced solar technology, though manufacturing capacity and access to rare earth minerals necessary for production lag behind those of Chinese competitors.

The European hydrogen economy represents another frontier of green technology development, with substantial investments in both blue and green hydrogen production technologies. European research institutions have pioneered advances in electrolysis efficiency and storage solutions, though commercialization challenges remain. The continent's strength in industrial processes and engineering has positioned it well for developing and implementing these technologies at scale if given the necessary tools.

This noted, there are challenges with complex regulations and difficulties in finding access

to cheap and easy investments as well as deregulation.[3] Compared to China, the bureaucratic complexities within the EU, combined with the relatively small investments in green technology, have put European innovation and commercialization of green technology behind the much more deregulated and well-funded Chinese initiatives. It has become increasingly apparent that European research and development lags behind that of the U.S. and China, even if under. Trump the U.S. focus on green development will be severely damaged. Mario Draghi, in his report on European competitiveness, called for a boost of research and innovation to EUR 800 billion annually, or 3 percent of GDP, a figure that should be considered to be doubled to ensure European long-term competitiveness.[4]

Supply Chain Vulnerabilities and Dependencies

Despite the progress in green technology, a closer look at Europe's supply chains reveals significant vulnerabilities that could impact the continent's ability to achieve its climate objectives and research and innovation security. The most pressing concern centers on the dependency on Chinese suppliers for critical components and raw materials essential to renewable energy technologies. This dependency extends across multiple technology domains and represents a strategic challenge for European industrial policy. Research and innovation forms a basic fundament of the supply chain, one that is challenged due to the failure to control basic raw materials in the chain.

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Recent data indicates that China controls approximately 85 percent of global rare earth element processing capacity, including neodymium and dysprosium, crucial for permanent magnets in wind turbines and electric vehicles.[5] The situation is particularly concerning for heavy rare earth elements, where Chinese dominance according to some estimates exceeds 99 percent of global processing capacity.[6] This concentration of control over critical materials creates a strategic bottleneck that affects multiple sectors of Europe's green technology development.

The lithium supply chain exemplifies these dependencies. Despite ambitious plans for domestic battery production, Europe remains heavily dependent on Chinese-controlled lithium processing capabilities. While raw lithium may be sourced from various countries, China's dominance in processing and refining creates a strategic vulnerability that affects the entire European battery industry. Similar dependencies exist in the cobalt supply chain, where Chinese companies control significant portions of mining operations and nearly 80 percent of global refining capacity.[7] This control extends to the production of cobalt-containing battery precursors and cathode materials, creating multiple points of dependency in the supply chain.

In the solar energy sector, Europe's dependencies are particularly pronounced. Despite having

pioneered many solar technology innovations, European manufacturing capacity has been severely eroded over the past decade. The polysilicon supply chain illustrates this vulnerability, as Chinese manufacturers control over 75 percent of global supply.[8] More critically, the integration of polysilicon production with wafer manufacturing has created a situation where European polysilicon producers are largely dependent on Chinese customers. This dependency extends further downstream. China's dominance in wafer production exceeds 95 percent of global capacity, creating a near-complete dependency for European solar panel manufacturers.[9]

A similar situation prevails in the electric vehicle battery supply chain. Chinese companies maintain control over approximately 70 percent of global cathode material production and 85 percent of anode material production, making European manufacturers heavily dependent on these critical battery components.[10] Despite recent investments in European gigafactories, there remains a significant technology and scale gap compared to Chinese manufacturers. This dependency extends beyond raw materials to manufacturing equipment and process knowledge, creating multiple layers of vulnerability in the supply chain. This concern has further been amplified as friction between Europe and China has intensified over the general competition within the EV sector, notably as China has increased its FDI in greenfield EV investments, and its overall FDI in Europe after a steady decline in the past seven years.[11]

The wind energy sector, while traditionally a European strength, also faces component-level dependencies that affect its long-term competitiveness. Direct-drive wind turbines rely heavily on neodymium-iron-boron permanent magnets, and China controls both the raw materials and manufacturing capacity. This dependency extends to specialized components,

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including large bearings and sophisticated electronic controls, where Chinese manufacturers have developed significant expertise and scale advantages. The reliance on Chinese-made specialized equipment and tooling for production processes adds another layer of complexity to these supply chain vulnerabilities.

The emerging hydrogen economy, while still in its early stages, is already showing signs of similar supply chain vulnerabilities. Dependencies on key components such as electrode materials and specialized membranes, which often rely on Chinese suppliers, potentially compromise European leadership in electrolysis technology design.[12] The supply of platinum group metals, essential for certain types of electrolyzes and fuel cells, faces potential constraints as China increasingly controls processing and recycling capabilities.

These supply chain vulnerabilities have profound implications for European industrial strategy, competitiveness and innovation. The concentration of upstream supply chain components in China affects the ability of European manufacturers to compete effectively across multiple green technology sectors. Moreover, these dependencies can constrain Europe's capacity to innovate and scale new technologies effectively, potentially undermining the continent's technological sovereignty in key green technology sectors.

European policymakers and industry leaders have begun implementing various strategies to address these vulnerabilities.[13] Efforts to develop alternative supply sources have led to new partnerships for raw materials with countries such as Australia, Canada, and various African nations. Significant investments in recycling technologies and circular economy approaches aim to reduce dependency on primary raw materials, while strategic programs to rebuild manufacturing capacity in critical supply chain components receive support from both EU and national funding sources. Recycling and circular economy strategies are of particular interest since they impact environmental security positively, as well as reduce the dependency on a Chinese controlled supply chain. Even if not sufficient by far, this is a positive development that indicates a understanding of the challenges.

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The building of strategic reserves for critical materials has emerged as another important mitigation strategy, providing a buffer against potential supply disruptions, not least in terms of research and innovation.[14] Simultaneously, increased investment in research and development focuses on alternative technologies that could reduce dependency on critical materials or enable substitution with more readily available alternatives. However, these initiatives require long-term commitment and significant resources to achieve a meaningful impact on supply chain resilience, and it is unclear if Europe has the political and financial commitment to ensure a long-term change.

The complexity of these supply chain vulnerabilities in the development of green technology requires a coordinated response that combines industrial policy, technological innovation, and international cooperation. European efforts to address these challenges must balance the immediate need for supply chain security with longer-term objectives for technological sovereignty and environmental sustainability. Success in this endeavor will require sustained investment, policy coordination across member-states, and strategic partnerships with reliable international partners.

Chinese Research Investment Strategies and Implications

The contemporary global research landscape is defined by complex intersections of academic

collaboration, technological ambition, and geopolitical strategy. At the heart of this intricate ecosystem, China has emerged as a sophisticated architect of international research engagement, particularly within European academic and technological institutions. This is a relationship that is not without problems and increasingly Chinese scholars and companies have been accused of spying and IP theft. China's approach to research investment transcends traditional models of academic exchange. It represents a complex form of technological diplomacy in which strategic national objectives intertwine seamlessly with academic collaboration and espionage. This methodology is not merely about funding or conducting research but about creating intricate networks of knowledge acquisition and theft, technological development, hostile take-overs, and long-term strategic positioning.

Initial collaborations often appear as standard academic partnerships—joint research projects, scholar exchanges, and collaborative publications. However, these interactions are carefully orchestrated to serve broader national technological objectives by PRC government institutions. European research institutions, with their cutting-edge innovations but with a rather naïve security orientation, have become conduits for technological knowledge transfer. Chinese entities strategically position themselves to absorb and adapt emerging technologies, often without the researchers' knowledge.[15] This is not a call to eliminate joint research, but to know the risks and challenges when initiating the joint activities. Chinese research and researchers will be a hub for the green transition, especially as the U.S. does not share the agenda of China, EU and much of the world.

Green technology has emerged as a particularly compelling domain of strategic investment. As global consciousness around climate change intensifies, technologies related to renewable energy, sustainable materials, and carbon-neutral innovations have become critical battlegrounds of technological supremacy. Chinese research strategies have demonstrated remarkable precision in identifying and engaging with European research centers at the forefront of these innovations without letting knowledge or resources flow in the "wrong" direction for the Chinese communist party.

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Battery technology exemplifies this strategic approach. European laboratories have been pioneering advanced energy storage solutions, exploring novel materials and chemical compositions that promise higher efficiency, longer lifespans, and reduced environmental impact. Chinese investment strategies have systematically targeted these research centers, establishing collaborative frameworks that provide deep access to emerging technological developments.[16] The result is a complex interaction of knowledge exchange, where European researchers gain substantial funding and resources while Chinese institutions acquire critical technological insights. This often happens without the European academics necessarily understanding that there has been a technology transfer, and loss of property rights, i.e. their research.

The hydrogen production sector highlights another arena of significant strategic engagement. As countries worldwide seek alternatives to fossil fuel energy systems, hydrogen emerges as a promising solution. European research institutions have been developing groundbreaking methodologies for hydrogen generation, storage, and utilization. Chinese research investors have demonstrated an acute understanding of the need for this technological landscape, creating collaborative mechanisms that allow for comprehensive technology transfer to China.

The Chinese strategy of technology transfer is not without considerable complexity and potential conflict. European institutions are becoming increasingly aware of the geopolitical implications of such collaborations, and the European Union has begun to act in a more preventive fashion rather than the more reactive mechanism that was in place before. The fine line between open academic exchange and potential technological vulnerability has become increasingly blurred. Governments and research institutions are developing more sophisticated screening mechanisms, implementing rigorous intellectual property protection strategies, and creating comprehensive frameworks for international research partnerships.

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The implications extend far beyond immediate technological acquisition. These research investments represent a form of soft power projection, allowing China to establish significant influence within global academic and technological ecosystems. Chinese institutions are positioning themselves at the forefront of emerging technological paradigms by creating deep, sustained research relationships. This would not be an issue, if innovations was shared equally and not weaponized in the political field, such as over Taiwan.[17]

Solar cell efficiency improvements offer another compelling narrative of this strategic approach. European researchers have consistently been global leaders in photovoltaic technology development. Chinese investment strategies have not simply sought to import these technologies but to understand their developmental trajectories in depth. Collaborative laboratories, joint research projects, and strategic funding mechanisms have allowed for a comprehensive engagement with solar technology innovation and a growing transfer of knowledge away from Europe to China.

As we move further into the 21st century, the landscape of international research collaboration continues to evolve. Technological diplomacy has become a critical dimension of global innovation, with research investments serving as sophisticated instruments of national strategy. China's approach represents a particularly complex manifestation of this phenomenon—a strategy that combines academic openness,

technological ambition, and long-term strategic vision. Understanding the dynamics of international research relationships, navigating their challenges, and recognizing their potential will be crucial for institutions, governments, and researchers seeking to remain at the forefront of global innovation.

Role of Academic Institutions

European universities and research institutions have become central to the dynamic between European green technology development and Chinese engagement. These institutions often face difficult choices between accessing valuable funding sources lacking within the EU, fighting a highly regulated bureaucracy in the EU and protecting sensitive research outcomes. The relationship between academic freedom and research security has emerged as a critical consideration in institutional policy-making, and this is in an environment that traditionally has valued academic freedom very highly.

Many European research institutions have developed significant collaborations with Chinese counterparts, leading to valuable scientific exchanges and joint publications, many of them initiated by European partners and funded by Chinese partners and sponsors. However, these relationships have also raised concerns about unintended technology transfer and protecting intellectual property rights. The challenge lies in maintaining the benefits of international academic collaboration while ensuring appropriate protection for sensitive technologies and research outcomes.

Knowledge transfer occurs through various mechanisms beyond formal research collaboration. Student exchanges, visiting researcher programs, and joint publication initiatives all serve as potential channels for technology transfer. While these mechanisms contribute to the global advancement of scientific knowledge, they also create pathways for the unintended transfer of sensitive technologies and know-how. This is not only about limiting the Chinese communist party's access to groundbreaking technologies but also about securing individual researchers' intellectual property rights, something that is often overlooked by the individual researcher.

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Industrial Partnerships and Technology Transfer Dynamics

The industrial sector represents another critical dimension of Europe-China green technology relations. Chinese investments in European clean technology firms have increased substantially, creating both opportunities and challenges for European industry. These investments often provide needed capital for technology development and commercialization but can also lead to concerns about long-term competitive implications.

Strategic acquisitions of European firms by Chinese entities have typically targeted companies

with advanced technologies in areas where China seeks to build domestic capabilities. These acquisitions often result in technology transfer that can enhance Chinese competitive capabilities while potentially reducing European technological advantages.[18] The pattern of acquisition suggests a coordinated approach to acquiring specific technological capabilities aligned with Chinese industrial policy objectives.

Joint venture arrangements between European and Chinese firms present similar challenges. While these partnerships often provide European companies with access to the Chinese market and manufacturing capabilities, they frequently require significant technology sharing. The terms of these arrangements can create pressure for European firms to transfer valuable intellectual property and know-how in exchange for market access. It should be realized that private companies do not exist in the same way in China as in Europe. Chinese legislation demands that "private" companies submit to Chinese national interests if necessary, and in many cases, the Chinese Communist Party is present on company boards and has a direct influence.

> ***Selective engagement with international partners, including China, remains important for advancing green technology development and coordination of global ambitions to reduce the climate challenge. However, this engagement should be guided by clear frameworks that identify areas where collaboration provides mutual benefits while protecting sensitive technologies and intellectual property.***

Policy Response and Regulatory Frameworks

European policymakers have begun developing more comprehensive frameworks to address these challenges while maintaining beneficial aspects of collaboration with China. The evolution of these policy responses reflects a growing awareness of the strategic importance of green technology development and the need to protect European interests while maintaining international collaboration.

Investment screening mechanisms have been enhanced at both EU and national levels, with particular attention to investments in strategic sectors including green technologies. These mechanisms aim to provide better oversight of foreign investments while maintaining Europe's openness to beneficial international capital flows. The implementation of these screening mechanisms has required careful balancing of security concerns with the need to maintain attractive investment conditions. For instance, the European Union introduced its Foreign Direct Investment Screening Regulation in 2020, which established a framework for coordinating national screening mechanisms and addressing security risks linked to foreign investments. At the national level, Germany tightened its investment screening rules in 2021 to include closer scrutiny of acquisitions in the renewable energy sector, recognizing its critical role in energy security and green transition efforts.[19]

Research security guidelines have also evolved, though implementation remains inconsistent across member states, but there is still a lack of clarity and an overlapping view between academic and security circles how far this should

reach. These guidelines aim to provide clear frameworks for evaluating research partnerships and protecting sensitive technologies while maintaining the benefits of international academic collaboration. The development of these guidelines has highlighted the need for coordination between academic institutions, industry, and government agencies. The challenge has been that academics have been asking for guidelines from the government, but governments has pushed over some of the responsibility to individual researchers and universities.

Supply chain resilience initiatives have gained momentum, supported by EU funding programs and policy frameworks, to secure the very base for innovation and research. These initiatives seek to reduce strategic dependencies through supply chain diversification and development of domestic capabilities in critical green technologies. The success of these efforts will depend on sustained investment and policy support over the long term, but it is evident that breaking the current dependency will take time and be costly.

Implications for Global Climate Action

The challenges in Europe-China green technology relations have significant implications for global climate action.[20] The pace of innovation required to address climate change necessitates international collaboration, yet security concerns and competitive dynamics can impede this cooperation. Finding the right balance between protection and collaboration remains crucial for maintaining technological progress while ensuring the security of strategic technologies.

The success of global climate action depends in part on the ability of major economies to work together while managing competitive dynamics and security concerns. The experience of Europe-China relations in green technology development provides essential lessons for managing these challenges while maintaining progress toward climate objectives. It is increasingly evident that

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European independence in green technology will delay the green transformation, but the question begs if there is a choice for Europe not to increase their independence in research and innovation security related to green technology? Exchanging a dependency on Russian oil and gas to one on Chinese green tech could make short term sense, but over time will have negative political and economic implications.

It would be positive for the climate if both circular economics and recycling were introduced to ensure a more effective use of resources already in play. Additionally, reintroducing a European processing capacity at scale would also be positive, both in terms of Europe's economic independence and innovation strength and because Europe has much stricter legislation when it comes to processing, which would ensure cleaner processing and a requirement to be connected to a circular economy.

Recommendations

Based on the analysis of current challenges and policy responses, several recommendations emerge for strengthening European green

technology development while managing research security concerns. A harmonized approach to research security and technology transfer across the EU would provide more precise guidelines for institutions and businesses while reducing regulatory fragmentation.

The development of strategic autonomy in critical green technologies requires targeted investment in domestic capabilities and supply chain development. This investment should focus on areas where European technological leadership is essential for achieving climate objectives and maintaining economic competitiveness. The selection of these focus areas should consider both technological feasibility and strategic importance.

To effectively mitigate research security risks while maintaining innovation and openness, the development of a centralized, publicly accessible research security toolkit and legal and regulatory database is something to consider. Such an initiative should provide higher education institutions (HEIs) and research centers across the EU with the necessary tools to assess, respond to, and prevent any forms of security breaches.

Moreover, having an integrated legal and regulatory database that offers detailed documentation and analysis of Chinese export control laws, dual use regulations, IP protections, and other ad hoc foreign legislation that may threaten European research integrity would be crucial. Ultimately, such a platform would reduce fragmentation, improve institutional response capacity, and foster greater alignment across the EU and with transatlantic partners in safeguarding strategic research.

Selective engagement with international partners, including China, remains important for advancing green technology development and coordination of global ambitions to reduce the climate challenge. However, this engagement should be guided by clear frameworks that identify areas where collaboration provides mutual benefits while protecting sensitive technologies and intellectual property. The development of these frameworks should involve consultation with academic institutions, industry stakeholders, and security experts.

Enhanced monitoring mechanisms for technology transfer risks and research partnerships would provide better visibility into potential security concerns while allowing for more informed policy responses. These mechanisms should incorporate quantitative and qualitative measures of technology transfer impacts and their implications for European competitiveness.

Circular economics and recycling must be implemented to ensure green technological development, and Europe's processing capacity of rare earth minerals must be increased as this continues to be a soft belly of Europe. Research and innovation could improve, but manufacturing of green technology still remains in the hands of China, unless a change is implemented.

Research Directions and Considerations

This issue brief suggests several important areas for future research and investigation. A quantitative assessment of technology transfer's impacts on European competitiveness would provide valuable insights for policy development. This assessment should consider both direct and indirect effects of technology transfer, including impacts on innovation capacity and market competitiveness.

Evaluation of policy effectiveness in protecting strategic technologies while maintaining beneficial collaboration requires ongoing research and analysis. This evaluation should consider both intended and unintended consequences of policy measures, including their impacts on research productivity and international collaboration.

The investigation of alternative supply chain configurations for critical green technologies represents another important area for future research. This investigation should consider technical and economic feasibility while accounting for strategic considerations and security requirements.

The relationship between European green technology development and Chinese engagement presents both opportunities and challenges for Europe's climate objectives and technological sovereignty. Success in navigating these challenges requires a nuanced approach that protects strategic interests while maintaining beneficial collaboration. The proposed policy framework provides a starting point for achieving this balance, though continued refinement and adaptation will be necessary as the technological and geopolitical landscape evolves.

The findings of this research hope to contribute to a broader understanding of international technology transfer dynamics and the intersection of climate policy with national security concerns. As Europe continues its green transition, maintaining technological leadership while engaging constructively with China will remain a critical challenge requiring careful navigation and strategic foresight.

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