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E-PAPER

Why US Export Controls on Clean Tech Would Backfire

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Introduction

In 2014 the US Department of Commerce published a report assessing the benefits of the International Traffic in Arms Regulation (ITAR), a set of unilateral export controls meant to protect the know-how of [American aerospace companies](#). The conclusions of the study turned out to be surprising. Most US firms believed that ITAR had hurt them; 35% of companies even reported that they had lost contracts because of the regulations, which imposed complex licensing requirements for the export of US-made satellites to Europe. In countless interviews, American executives explained that the measures had only served to encourage the development of cutting-edge space technology outside the US, out of reach of Washington's export controls. A [respondent noted](#) that without ITAR, "it is unlikely that the European space industry would have grown so significantly, so quickly."

Hard data appeared to support the complaints of American businesses. The US share of the global space market stood at 75% in 1998, when Washington started to enforce the ITAR rules in a bid to cement the US leadership in the field. Within ten years, America's global market share for space equipment, such as satellites and satellite parts, had dropped below 50%. Many small US businesses found themselves unable to survive and had to exit the market. As part of the survey, one firm bluntly reported that the regulations had been "very successful in creating a global network of companies making competing products while ensuring US companies cannot compete." Three years after the publication of the report, Washington scrapped the aerospace sector from ITAR rules in an attempt [to restore the competitiveness of the US space industry](#).

More than two decades later, US clean tech firms worry that history could repeat itself. In early 2023 the administration of Joe Biden, the US president, appeared on the verge of imposing ITAR-like measures on mainstream clean tech goods – solar panels, wind turbines and batteries for electric vehicles (EV). The fears of US clean tech firms were not unfounded. Export controls are a key tool for Washington to implement its [China-focused de-risking strategy](#), which aims at ensuring that the US remains the world's sole tech power and does not facilitate the advances of the People's Liberation Army (PLA). These measures target technologies that have [dual-use applications](#), such as semiconductors (used in modern defence gear, like missiles), artificial intelligence (which can power autonomous killing robots) and quantum technology (which can break encryption protocols, including military ones).

In the end the US decided not to impose controls on exports of clean tech goods; only the shipments of some clean tech materials, such as fiberglass for wind turbines, and of some equipment used to produce renewable energy gear [require US export licenses](#). Instead of adopting export controls, the administration chose to target dealings where Chinese firms are suppliers of green energy goods – not buyers of American technology. Two measures

highlight this strategy. In November 2022 Washington included advanced clean energy goods as an area for enhanced inbound foreign investment screening (through the Committee on Foreign Investment in the United States, CFIUS). In December 2023 Washington announced that electric vehicles that use a battery made with Chinese components or manufactured by a firm with ties to China would not be eligible for federal subsidies planned in the Inflation Reduction Act (IRA).

The reasons why the administration chose not to impose export controls on the clean tech sector remain unclear. One possible explanation is that green energy goods are not a good fit for America's de-risking strategy. Clean tech products can certainly be weaponised; in February 2023 a Russian-sponsored cyberattack [shut down nearly 6,000 wind turbines in Ukraine](#). In addition, China's policy of [military-civil fusion](#) blurs the line between the civilian and defence sectors. However, clean tech hardly qualifies as dual-use equipment: solar panels and wind turbines are unlikely to ever help to kill anyone and they do not directly contribute to the development of the PLA. A second possibility is that Washington feared fuelling tensions with European allies at a time when transatlantic collaboration is critical, in particular on Russia sanctions. American controls on clean tech exports would be unilateral measures, given the lack of appetite for such a policy in the EU at this stage. As a result, such controls would undoubtedly reignite US-EU rows over American extra-territorial economic measures. A third option is that the US is keen to keep some powder dry in case US-China tensions escalate further, for instance over Taiwan. In such a case, it would make sense to spare clean tech from such controls for now in a bid to retain leverage over China.

Yet beyond these straightforward reasons there is also an inconvenient truth. US controls on clean tech exports to China would likely be ineffective: Beijing is the world leader for the production of green energy goods and Chinese firms already have ample access to clean technology. This sobering assessment illustrates the fact that unilateral export controls can only work for technologies where the US has a global edge, such as semiconductors. In addition to being ineffective, American controls on clean tech exports to China could well backfire: such measures might undermine the development of US clean tech firms designing the next generation of green energy goods (like advanced batteries, electricity storage or low-carbon hydrogen), weighing on American attempts to catch up with China in the clean tech sector. Such policies would also have negative ripple effects beyond US borders: they would strain relations with allies and fuel global resentment against western democracies by showing that the US is not shying away from weaponising access to goods that are crucial for the fight against climate change.

China is the World Leader for Clean Technology

Clean technology is a key battleground in the US-China conflict for economic dominance. China's goal is to be the world leader for clean technology. This strategy is not new: in 2015 Beijing identified renewable energy as one of the key sectors for its [Made In China 2025 industrial blueprint](#), a roadmap for industrial and technological advances that unlocked massive subsidies for state-owned and private firms alike. Beijing's focus on clean tech reflects the fact that the global stakes in the field are enormous. Two statistics illustrate this: first, by 2050 around [90% of the world's electricity](#) supply could come from renewable sources of energy. Second, in a net-zero scenario the annual global capacity additions of low-emission sources of energy would quadruple, [reaching 1,260GW](#) per year in 2050. China's strategy in the renewable energy field is also linked to domestic security considerations: Beijing is keen to increase the supply from all sources of energy – be it coal, oil, gas, nuclear, solar, hydro or wind – in a bid to strengthen energy security.

China has achieved its ambition of becoming the world global leader for clean tech. Chinese firms are, by far, the leading manufacturers of green energy goods. The country is home to most of the world's leading companies in the field and it accounts for [70-80% of the global manufacturing capacity](#) for the 12 most important components used to manufacture EV batteries, solar panels and wind turbines. China's domination for the production of green energy goods spans across all three key sectors of clean tech:

- *Electric vehicle batteries:* Chinese companies manufacture around [three-quarters of lithium-ion batteries used for EVs](#). A single Chinese company, CATL, [powers about one-third of EVs worldwide](#). China's edge extends across all the echelons of the EV battery supply chain: the country produces 70% of cathodes and 85% of anodes for EV batteries, for instance.
- *Solar panels:* China manufactures [80% of global solar modules](#), with an output of more than 500GW per year (equivalent to around 500 typical nuclear reactors). The country is home to the [world's largest companies in the field](#) (by shipment volumes), including LONGi Solar Technology, JASolar, JinkoSolar, Trina Solar and Risen Energy.
- *Wind turbines:* Chinese firms account for [40% of the global manufacturing capacity for wind turbines](#). China's domination is even higher for the [production of nacelles](#), which house the turbine's power generation equipment; the country has a market share of [60% in this field](#) and is currently building more than 60 nacelle assembly facilities. Further down the supply chain, China holds a market share of 70% for the manufacturing of several crucial components for wind turbines, such as castings, forgings and towers.

China's edge over the clean tech sector will remain unchallenged for a long time to come. Beijing keeps investing massively to further increase its manufacturing capacity for clean tech goods, cementing the country's global production edge. One data point says it all: China accounted for [91% of global investment in clean tech manufacturing capacity](#) in 2022, for a total of around US\$72bn. China's green energy transition will also support the development of clean energy supply chains in the country: Beijing invested US\$546bn in its energy transition in 2022, accounting for around half of global financing. This eye-popping amount is not a one-off: analysts forecast that Chinese investments for the country's green energy transition could average [US\\$386bn](#) per year by 2050 (or a whopping US\$10trn in total – equivalent to more than half of China's current nominal GDP).

China's domination of the clean tech sector would make US export controls in the field moot. Such measures, which aim at depriving adversaries from access to American technology, date back to the Cold War. The US has resurrected export controls to tackle China's economic rise in recent years, but these policies may not be a good match to tackle Beijing's ascent. US export controls initially targeted a moribund former Soviet Union that had little capacity to undertake top-notch R&D. (Measures restricting Moscow's access to US technology started in 1949, but their scope was limited until the Soviet invasion of Afghanistan in 1979.) By contrast, China is a vibrant economy that is making great strides in the technological sector. More importantly, unilateral export controls can only work in fields where the US is the sole global leader, such as microchips. A look at the manufacturing process to build semiconductors illustrates this analysis. Most chips are manufactured in Taiwan or South Korea, but a handful of US companies [control the upstream echelons of the supply chain](#) for semiconductors. Three American businesses (Cadence Design Systems, Synopsys and Mentor Graphics) capture 85% of the market for [microchip design software](#), the first step in the creation of a semiconductor. The market leaders for the [sophisticated industrial tools that equip foundries](#) are US-based, too: Applied Materials, Lam Research, and KLA-Tencor control nearly half of the market for semiconductor manufacturing equipment (ASML, a Dutch firm, is another world leader in the field). Finally, the US domination over the semiconductor sector also extends to other [specialised parts of the manufacturing chain](#); American suppliers hold a market share of roughly 80% for such obscure processes as wafer inspection, chemical vapor deposition or rapid thermal processing. To put things differently, the powerfulness of US export controls on semiconductors derives from America's control of the technology at all steps of the semiconductor supply chain; there is simply no alternative to US know-how in the field. By contrast, America does not have such an edge over the clean tech field: China already has access to the technology to produce clean tech goods at scale. As a result, restrictions on US exports of green energy-related know-how would likely have only little impact on Chinese firms.

China has leverage over the US in the clean tech field. Beijing's domination of the clean tech sector gives the country huge leverage over Washington. In particular, Chinese firms control the supply of critical raw materials (CRM), such as lithium, cobalt or copper, that are crucial to manufacture clean tech products. Two statistics illustrate this: China sup-

plies [90% of the processed raw materials](#) that are necessary to build EV batteries and Chinese firms [own or co-own 15 of the 19 cobalt mines](#) of the world's largest producer of cobalt, the Democratic Republic of Congo (DRC). China's domination over the CRM supply chains has key implications for America's clean tech sector: even if the US becomes self-sufficient for battery production around 2025 (as looks likely), the country will remain [almost entirely dependent on China for raw materials for decades to come](#). At this stage recent Chinese threats to ban exports of CRM [are probably a bluff](#), as they would undermine China's domination over the CRM sector. Yet they still need to be taken seriously: a 30% cut in the supply of gallium available to American factories, for instance, could [shave around 2 percentage points from US GDP growth](#) (an economic hit similar to that taken by Europe following the interruption in Russian gas supplies). Further down the supply chain, China could also impose its own controls on clean tech exports. This scenario is not inconceivable: in January 2023 Beijing signalled that it was considering imposing [export controls on solar panel technology](#). Such a move is unlikely, given it would destroy China's edge over the solar panel sector and undermine the prospects of Chinese firms in the field. However, a Chinese decision to deny exports of solar panels (or other green energy goods) is not unthinkable in a scenario of heightened US-China tensions. Such a policy would come with huge consequences for the US: such a step would slow down America's energy transition, given the US reliance on Chinese-made solar panels. Similar Chinese threats, even if they remain hypothetical at this stage, explain the concerns of US national security advisor Jake Sullivan that [clean tech supply chains could end up being weaponised like oil was in the 1970s](#).

US Export Controls Would Derail American Plans to Catch up with China in the Clean Tech Sector

The US plans to strike back and challenge China's dominance in the clean tech sector. The development of an American clean tech sector represents a priority for the US administration. The stakes are high for the US, owing to three assumptions. First, the green energy transition presents a once-in-a-lifetime opportunity to [rejuvenate the US rust belt](#) through massive clean tech-linked IRA subsidies; the scheme pencils in [federal investments](#) of more than [US\\$800bn to develop and install clean energy in 2023-31](#) via nationwide infrastructure projects, grants, loans and tax credits. This has an important political implication for the Biden administration: several swing states for the November 2024 US presidential election, such as Pennsylvania, Wisconsin and Michigan, form part of this rust belt of millions of registered voters. Second, the global market for green energy gear is massive. Industry groups estimate that annual global spending on clean tech goods will amount to a [whopping US\\$0.8-1.1trn by 2030](#). America wants a share of the clean tech pie; the [US Trade Department](#) has made supporting the competitiveness of US clean tech firms a priority. Third, Washington assumes that China is more dangerous as a supplier than as a customer for clean tech goods, making the development of US-made (or at least non-Chinese) green energy gear a priority. This assessment mostly reflects suspicions that Beijing has means to remotely disrupt the operations of Chinese-made clean tech gear, threatening US energy security.

America's goal to catch up with China will be a tall order for clean tech manufacturing. Two [data points highlight how the US is far from being a leading player](#) for the production of green energy goods. First, the country captures only around 13% of the global market for clean tech, a share that has remained broadly stable since 2019. By comparison, China accounts for about one-third of the global market for clean tech. Europe (defined as the EU27 and the UK) comes second, capturing 27% of the global market. Second, American exports of clean tech stand below 0.5% of US GDP, compared to an impressive 4% in Germany and nearly 1.5% in China. For America, the patch to challenge China's manufacturing edge looks steep across all clean tech sectors:

- *EV batteries:* America manufactures only 7% of the world's EV batteries. Even accounting for massive IRA-related subsidies, the US should not account for more than [13% of global manufacturing capacity for EV batteries by 2030](#). More broadly, this bleak picture reflects the US's gradual loss of leadership for EVs: America's share of the [global EV market](#) stood at only [10% in 2022](#), down from above 25% in 2019.

- *Solar panels:* The US holds only [around 1% of the world's manufacturing capacity](#) for solar panels. Only one major American company, First Solar, [manufactures solar panels on US soil \(in Ohio\)](#). Most solar panels installed in the US come from Chinese firms producing either in China or in south-east Asia (notably in Vietnam, Thailand and Malaysia).
- *Wind turbines:* The US accounts for less than 5% of the world's manufacturing capacity for wind turbines despite boasting major players in the field like GE. The sector is going through a rough patch, with lengthy delays to get new US installations connected to the grid. In addition, inflation is fuelling the price of raw materials, weighing on the development of new projects. As at end-2023, [more than half of US offshore wind projects are cancelled](#) or at risk of being cancelled.

The US can still lead for the next generation of clean tech products. American firms have probably lost the battle against China for the manufacturing of the current generation of green energy goods. However, the US may still become a major player for the next generation of clean tech gear, which remains under development. The stakes for American clean tech startups are huge: [around 75% of the planned CO2 emissions cuts by 2070](#) will come from technologies that remain at prototype phase or have not been commercially deployed yet. Such next-generation areas of clean tech include:

- *Advanced EV batteries.* Chinese-made EV batteries face two issues. First, China's batteries typically have only limited range, reflecting the fact that Chinese consumers usually drive only short distances in big cities. This makes such batteries unsuitable for American consumers, who usually drive long distances. Second, Chinese-made lithium-ion batteries require huge amounts of critical minerals. American firms could tackle both issues and lead the development of next-generation batteries. Such work could take place in partnership with other innovative western firms like South Korea's Samsung (which is designing longer-range batteries) and Sweden's Northvolt (which has created batteries that do not require [lithium, copper or cobalt](#)). Huge recent investments in the sector would support a [US push in the field](#); between August 2022 and March 2023 major EV manufacturers announced around [US\\$26bn in IRA-linked investments in battery manufacturing in North America](#). Fears around the sustainability of Chinese EV battery firms are an additional factor; China's production of low-cost batteries [could be twice higher than global demand by 2030](#), casting doubts about the prospects of Chinese battery companies.
- *Energy storage.* Because solar and wind power are intermittent, [energy storage](#) will be key to balance the grid as the share of renewable power increases in the energy mix. Energy storage projects remain mostly at R&D stage so far, with China leading the way; Chinese researchers published [half of global papers](#) on the topic in 2022 (around five times more than American scientists). However, experts reckon that there is scope for more US involvement in this R&D intensive area, especially as many [energy storage projects in China are struggling](#) with low utilisation rates and safety issues. The

Biden administration appears to share this view: in September 2023 Washington announced federal funding of [US\\$325m for 15 energy storage projects](#) across the US.

- *Low-carbon hydrogen.* Low-carbon hydrogen is a [promising option](#) to help meet a net-zero emissions target by 2050. So far China [leads in the field](#), but the country's goals appear modest and it lacks control of advanced technology in the area. The [amounts at stake are huge](#): the global market for low-carbon hydrogen could represent more than [US\\$500bn per year by 2050](#) (this figure may be an overestimate, but it still gives a ballpark idea of the potential future size of the sector). The US administration is keen to facilitate the development of low-carbon hydrogen technology: in October 2023 Washington announced [US\\$7bn in investments](#) for the creation of seven clean hydrogen hubs, in particular in Texas and California. Low-carbon hydrogen is another area for potential collaboration between like-minded allies: in May 2022 G7 economies launched a [Hydrogen Action Pact](#) in a bid to facilitate co-operation in the field.

Export curbs would derail US plans to have a global edge for the next generation of clean tech. On paper, export controls on those R&D intensive fields that will foster the development of next-generation clean tech products looks like a promising idea to protect US firms operating in the field. In practice, this assessment is flawed for at least two reasons. First, it is [not clear that export controls are effective](#) at ensuring that China does not catch up with the US for advanced technology. Despite stringent US export controls, it took only three years to Chinese firm Huawei to design and manufacture [cutting-edge semiconductors](#) that power a 5G mobile phone. Industrial-scale corporate espionage, massive state subsidies and a government-led push to develop high-tech products are all helping China to catch up with the US in critical technology fields. Second, this analysis ignores the fact that even a small drop in R&D expenses typically comes with huge long-term consequences for innovative firms. The US telecommunications sector offers [a good illustration of this](#). In the 1990s three US firms—Lucent, Nortel, and Motorola—dominated the global telecommunications sector. These three giants looked too big to fail, until the bursting of the tech bubble in the early 2000s prompted a sharp drop in their revenues. As a result, the American telecommunications giants had no choice but to cut R&D spending to stay afloat. Within only ten years, this drop in R&D expenses meant that the US telecommunications sector became only a shadow of its former self, lagging behind European and Asian peers for innovation. This cautionary tale could repeat itself in the clean tech sector: export controls would curtail the revenues of American green energy firms and, therefore, weigh on their R&D budgets. Meanwhile, non-American companies would gain new contracts in the markets that cannot work with US companies anymore. As a result, these rivals would be able to double down on R&D, helping them to surpass US firms over time. This analysis illustrates how US unilateral export controls are a double-edged sword. Such measures work well to deprive a target of access to a specific technology in the short-term. However, they also weigh on the longer-term prospects of American firms while facilitating the advances of their competitors.

Export Controls on Clean Tech Would Come with Global Side Effects

Republicans have [made it clear](#) that they would adopt a [more hawkish stance on China](#) and seek to apply export controls to a [broader range of sectors](#) than the Biden administration did. In addition, [Republicans do not see the need to prioritise the green energy transition](#) over the perceived need to tackle China's behaviour, making clean tech an obvious target for additional export controls on China. This take also reflects scepticism among Republicans over the reality of the green energy transition. Many Republican policymakers do not believe that a global shift to renewables is under way. In turn, they are not concerned about the need to avoid harming the interests of US clean tech firms. Most Republican voters – [up to 80% according to some polls](#) – do not think that climate change is a threat anyway. Around 70% of them also do not believe that global warming is a major factor in extreme weather events. Scepticism regarding the reality of climate change among Republicans has an important implication: the moral argument that clean tech should be spared from export controls, given green energy goods are crucial to tackle climate change, would be moot among many Republicans.

US unilateral export controls on clean tech would fuel transatlantic tensions. The election of a Republican president in November 2024 would probably reignite economic disputes between both sides of the Atlantic. Export controls would represent a key battleground for a revival of the Trump-era US-EU trade conflicts: under a Republican presidency, there is little doubt that the US would try to coerce allies to impose similar measures. There are precedents for this: in 2023 the US pressured ASML, a Dutch manufacturer of semiconductor manufacturing equipment, to [stop exports of key equipment to China](#). Export controls on clean tech would be unpalatable for the bloc, not least because such measures would clash with the EU's current de-risking policies; [Europe's list of critical technologies](#) focuses solely on goods that have military uses (such as semiconductors or quantum computing) or carry human rights applications (like biotech and AI). Based on these two criteria, at this stage the EU list does not identify clean tech as a candidate sector for export controls. From a broader perspective, US attempts to force the EU to curb clean tech exports would fuel the long-standing view among many European policymakers that America uses economic statecraft tools, such as sanctions and export controls, to advance its own economic interests. That Europe is currently capturing a larger share of the global clean tech market than the US would further reinforce these suspicions.

Curbs on clean tech exports would boost China's efforts to set standards for green goods. Given China's edge in the clean tech field for solar panels, wind turbines and EVs, it is unlikely that US export controls would delay the global energy transition: even if the US were to stop exports of clean tech products, developed and developing economies alike

would still have access to cheap China gear. As a result, US unilateral export controls would have the perverse effect of locking in many countries around the world into China's orbit for clean technology. Such a scenario would reinforce Beijing's ability to set technical standards in the field. This is far from a trivial issue: the race to set technical standards forms a key part of the conflict for economic dominance between China and western economies. As Werner von Siemens, who later founded the Siemens empire, [neatly summarised it](#), "He who owns the standards, owns the market." China's [digital Belt and Road Initiative](#) gives an illustration of this. The equipment that [smart cities use as part of the digital silk road](#) relies on Chinese technology. Upon signing up for the digital silk road, governments might not realise that they are signing up for a Chinese set of technological standards. Once the Chinese networks are up and running, it is too late (and often too expensive) for governments to change their mind. Emerging countries [find themselves locked in](#) with Chinese technology, [giving a long-term advantage to Chinese firms](#) over American ones. This scenario could well repeat itself in the clean tech field, further cementing China's global edge over the sector, including for the next generation of clean tech goods.

Restrictions on clean tech exports would fuel the perception of western double standards. Resentment against western countries is running high in many emerging economies. Global [perceptions of the war in Ukraine](#) illustrate this situation; the prevailing mood outside western states is that [like-minded democracies are applying double standards](#) with Ukraine – reacting more to war on their doorstep than to other recent land grabs or bloodsheds. US controls on clean tech exports would reinforce this trend. The recent COP28 in Dubai has shown that many emerging economies are reluctant to implement curbs on their CO2 emissions, arguing that they are not keen to slow down their own economic development because of the past emissions of western states. Even among those developing countries that are keener to tackle climate change, the mood is that decarbonation goals can be met only if rich economies provide both ample financing and access to clean technology. Unilateral curbs on America's clean tech exports would reinforce the scepticism from emerging economies regarding the reality of western commitment to the global energy transition: such measures would fuel the view that the US is not shying away from weaponising access to green energy goods despite them being crucial for the global fight against climate change. This would play into Beijing and Moscow's hand: in such a scenario, the Chinese and Russian propaganda machines would have a field day calling out the perceived hypocrisy of such restrictions.

Conclusion

As always with de-risking, it is useful to take a step back and consider things from China's perspective. Seen from Beijing, US unilateral export controls on clean tech goods would fuel the long-held view among Chinese policymakers that the US is willing to do anything it takes to curb China's economic rise. From a longer-term perspective, the Chinese leadership probably sees a technological decoupling from the US as a positive step, though. As Song Guoyou, a leading Chinese scholar, [puts it](#): "The further the US goes in decoupling from China, the less important it will become for China's future economic and technological development, and the more independent and autonomous China's development will be."

This assessment carries important implications for US national security. If Beijing were to invade Taiwan, US sanctions on China would be effective only if trade, financial and technological ties between America and China are strong. This reasoning holds in the clean tech sector: China's edge over the field can last only while it finds customers for its clean tech goods, including in the US. The Biden administration had solid reasons to spare clean tech from export controls: such measures would decrease ties between both sides of the Pacific in a field that has no dual-use or human-rights applications, fail to undermine China's global manufacturing edge in the sector and weigh on US attempts to become the world leader for the next generation of green energy goods.

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