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The Climate Risk of Green Industrial Policy

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In 1997, the prospect of expanding the use of wind energy in China seemed to be decades away. The country had a meager 80 megawatts of wind power capacity installed—equivalent to a single modestly sized wind farm today. Yet some agencies within the Chinese government, including the State Economic and Trade Commission (since merged into the National Development and Reform Commission), already saw the potential for China not only to expand its deployment of wind technology, but also to play a key role in manufacturing it. The country implemented two policies that year mandating that a percentage of all wind turbine equipment for local use be manufactured locally.

Over the following two decades, China rose to become the world leader in wind energy use—a rank it obtained by simultaneously developing the world's largest wind-power equipment manufacturing base. Through a series of strategic international partnerships, supported by local manufacturing requirements, China has become a leader in innovation for onshore and offshore wind turbine technology. China's rise in the wind power industry was the first in a series of successes in its development of modern low-carbon technology industries. It would be followed by similarly rapid rises in industries such as solar photovoltaics and lithium-ion batteries.

China's massive expansion into renewable energy manufacturing and deployment is also helping to achieve global climate goals. According to International Energy Agency projections, current renewable energy generation must increase more than eightfold in order to achieve net-zero emissions globally by 2050. China alone is responsible for deploying around 278 gigawatts (GW) of wind power capacity, nearly 60 percent of which has been installed since 2015, and 95 percent since 2010. That is almost twice the scale of the country with the next-largest wind power capacity, the United States.

China has installed even more solar capacity: an estimated 414 GW, more than double that of Europe. China added 106 GW in 2022 alone—almost double the installations of the previous year. And China is now repeating this ascent in manufacturing the batteries being used in electric vehicles (EVs) and energy storage. It currently has about 900 gigawatt hours of battery manufacturing capacity, or approximately 77 percent of the global total.

These successes having global consequences. China's rise in the clean energy sector, once encouraged by the West as a climate mitigation strategy, is now feeding competitive tensions and fostering a proliferation of green industrial policy measures that aim to extricate nations from many of the sector's global linkages. China's entry into the wind and solar industries fostered an increasingly globalized supply chain, which has led to an increase in the frequency of trade-related disputes and the implementation of tariffs and sanctions, via both the World Trade Organization and domestic channels. Many such tariffs and sanctions target China's green industrial policy strategy, which includes local content requirements as well as domestic subsidies supporting locally made clean-energy technology.

We are seeing a resurgence in the use of industrial policy by the very countries that long advocated against such measures, given that they can be hard to get right. Industrial policy is essentially a set of government interventions that aim to promote the development of a specific industry or

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industries. As such, they require governments to pick winners, and pushing for local industrial development often comes at the expense of international competition and trade.

Historically, industrial policy has been used by emerging economies as a means of catching up with more technologically advanced nations. This was most notably observed in the East Asian developmental states in the 1970s and 1980s. Although there are certainly noteworthy examples of government intervention in innovation systems in the United States, such as the development of Silicon Valley and the Route 128 biotechnology cluster in the Boston area, for the most part American policymakers have criticized industrial policy interventions in countries like Japan and South Korea, and now in China.

The current industrial policy resurgence in the West can be linked both to China's unprecedented industrial rise and to a reframing of climate and clean energy policy as economic policy, as opposed to a more narrow environmental policy. The political economy of clean energy development is based on the fact that these technologies require state subsidies to compete with more traditional energy technologies—and states want to reap direct economic benefits from their investments.

For decades, attempts to pass climate legislation in the United States were based on carbon pricing mechanisms such as a cap-and-trade system or a carbon tax, and failed when such policies were framed as imposing a cost on the economy in return for an environmental public good. Green industrial policy skirts this problem by recasting climate policy as strategic economic policy, and by focusing on the local benefits to clean-energy technology development rather than the costs of climate mitigation.

The resurgence of industrial policy places the political economy of domestic renewable energy support in direct conflict with the basic principles of global trade regimes and globalization. Simultaneously, there are calls for decoupling clean energy supply chains from China, since its dominance in the production of many clean energy technology components may create economic or security risks for the countries that rely on them. Yet greater use of industrial policy to develop domestic clean energy industries, along with the decoupling of clean energy supply chains from China, could actually slow the global clean energy transition. It may increase the cost of deployment in the developing world, constraining the ability of nations to shift to low-carbon economies.

CHINA'S CLEAN ENERGY ASCENT

The promotion of clean energy in China is anchored in a broad-based green industrial policy. In its efforts to develop high-tech industries, the Chinese government has gradually become more selective and restrictive about the types of imports and investments it allows. It prefers to leverage its own domestically manufactured technology to foster and strengthen Chinese industries.

China's use of industrial policy has been an integral part of its overall development strategy for the renewable energy industry over the past two decades. The 2006 "Medium- and Long-Term Plan for the Development of Science and Technology" introduced the concept of "indigenous innovation," which would become a term dense with subtext about China's strategy to become entirely reliant on self-designed technology built up from foreign knowledge. In 2010, the identification of seven Strategic Emerging Industries singled out the clean energy industry as one area that would be targeted for state support and for leveraging access to China's market in exchange for foreign technologies. However, it was the "Made in China 2025 Roadmap," released in 2015, that really put China's green industrial strategy on the map globally, due to the scale of its reach and specific calls to employ protectionism to achieve its goals.

Meeting ambitious global climate goals without China is nearly impossible.

Since then, China has become a central node in supply chains for many technologies critical to the clean energy transition. As a result of this supply chain dominance, meeting ambitious global climate goals without China is nearly impossible.

Global production is currently most concentrated in China in the solar industry. The country controls more than 70 percent of global production in each segment of the industry's supply chain. China is home to more than 80 percent of global polysilicon production, it makes virtually all of the wafers required to manufacture solar photovoltaic cells, and it accounts for 85 percent of global cell manufacturing and 71 percent of module assembly.

In the wind industry, China is a key producer of the rare earths (such as neodymium and praseodymium) required for the production of magnets used in gearboxes and gearless wind turbine designs. China is also a major producer of wind turbine components. Chinese firms hold 73 percent of global market share for the housing for the generating components (nacelles), and 59 percent for wind turbine blades, though most of these components are used within China to meet domestic demand.

In the battery sector, China currently accounts for more than three-quarters of global cell manufacturing capacity. It is also a major refiner of raw materials and metals required for battery manufacturing. More than 60 percent of global lithium refining currently takes place in China. China is also the largest refiner of cobalt, holding 72 percent of global market share.

Furthermore, China's entry into wind and solar and now battery supply chains has brought about dramatic cost reductions. Since 2009, the cost of wind and solar energy has decreased by 72 and 90 percent respectively. This has made clean energy technologies more affordable around the world, and more attractive to developing countries, which are still building the majority of new coal plants.

Most clean energy deployment needed in the future will be in the developing world. Countries across Africa, Latin America, and Southeast Asia have announced ambitious clean energy development goals in their climate plans, which currently rely on inexpensive technology from China. As manufacturing shifts to countries with higher labor and materials costs, prices will no doubt rise, making these technologies less accessible to developing countries.

WASHINGTON'S RESPONSE

Faced with China's emerging dominance in the clean energy sector, many other countries have turned to green industrial policies in recent years. The United States' policies have received global attention due to both their scale and their embrace of protectionism.

In recent decades, US clean energy policymaking primarily focused on innovation and deployment, as opposed to manufacturing. The United States has been the leading public investor in clean energy research and development. Federal and state policies, including tax credits and renewable portfolio standards mandating specific shares of renewable energy generation, helped to create domestic markets for these technologies. But there was minimal focus on domestic manufacturing or addressing deficiencies in clean energy supply chains. Industrial policies targeting the clean energy sector were primarily implemented indirectly through regulations, tax incentives, and trade rules.

Key initiatives under the Obama administration included the 2009 American Recovery and Reinvestment Act (ARRA) as well as a $400 million appropriation to fund the newly created Advanced Research Projects Agency–Energy (ARPA-E). The ARRA included a $60 billion loan guarantee program administered by the Department of Energy to support clean energy projects, including some investments in domestic manufacturing capacity. ARPA-E was designed to support the development of pre-commercial clean energy technologies.

The US Inflation Reduction Act (IRA) of 2022, often called the country's most ambitious climate legislation to date, is expected to generate between $355 and $552 billion in spending on climate mitigation and adaptation through 2031. The IRA also marks a clear shift from decades of failed US legislation focusing on market-based climate legislation, pivoting instead to a green industrial policy strategy. It is now viewed as a key part of a national effort, combined with the 2022 CHIPS and Science Act and the 2021 Bipartisan Infrastructure Law, to expand clean energy manufacturing within the United States, motivated largely by competition with China in these industries.

The IRA includes tax incentives to encourage EV purchases as well as revised tax credits to expand the deployment of wind, solar, and geothermal electricity, along with funding for loan guarantees for energy projects. But the law goes beyond previous support schemes by tying the eligibility of these tax credits to where the technologies are manufactured. Although some "Buy America" provisions were included in ARRA, they were nowhere near the scale of those found in the IRA.

In order to qualify for the IRA's full EV tax credit, at least 40 percent of the materials used in a vehicle's battery must be mined and refined in the United States, or obtained from a country with which the United States has a free trade agreement. The EV battery and its components, which are the highest-value parts of an electric car, must be manufactured in North America. In addition, the IRA's tax credits for investments in and generation of zero-emissions electricity provide "bonus credits"

for clean energy technologies manufactured in the United States.

In another part of the shift toward green industrial policy in the United States, a set of trade-related policies and measures is being used to protect US firms from allegedly unfair import competition. Title III of the Defense Production Act (DPA) has also been invoked by the Biden administration to address clean energy supply-chain dependencies on imports that may pose risks related to national defense and security.

The DPA allows the US government to offer minimum order guarantees, provide loans to manufacturers, and put in place domestic content standards to increase domestic manufacturing capacity—measures that might otherwise conflict with international trade law. The Biden administration has also been conducting an economic and security review of domestic supply chains, including critical industrial sectors, focusing specifically on reliance on Chinese inputs for key technologies.

FOREIGN ENTITIES

The impact of the IRA on investment in clean energy technology manufacturing in the United States is already visible. An estimated $137 billion in new investments has been announced, largely within the electric vehicle supply chain (including critical mineral production, batteries, chargers, and vehicle assembly) and in solar manufacturing facilities. But because most IRA credits are tied to local manufacturing, questions remain about how foreign partnerships to manufacture technology in the United States will be treated.

Green industrial policies must not come at the expense of poorer countries.

Many of these questions surround the fact that the IRA limits the sourcing of materials from companies identified as "foreign entities of concern," associated with non-allied countries such as North Korea, Russia, Iran, and, most notably for the clean energy sector, China. As of 2024, vehicles seeking to qualify for the IRA's EV tax credits "cannot have battery components manufactured or assembled by a foreign entity of concern." As of 2025, "qualifying vehicles' batteries cannot contain critical minerals extracted, processed, or recycled by a foreign entity of concern."

The term "foreign entities of concern" is also used in the CHIPS and Science Act. In September 2023, the US Commerce Department released further guidance on the term in response to stakeholder comments, primarily from US companies. Firms complained that it was difficult for them to determine whether a foreign entity falls into this category, especially in the case of small, seemingly independent research and development entities created by China, which are difficult to track. They asked for the definition to be limited to the Bureau of Industry and Security's Entity List. The Commerce Department declined to make this change, instead placing the responsibility for due diligence on US companies involved in such partnerships.

Though the US Treasury Department has not yet released any IRA-specific guidance on this term, it is likely that the Commerce Department's interpretation has direct implications for the IRA, particularly for the Section 30D EV tax credit, by restricting the sourcing of battery components or critical minerals from companies located anywhere in the world if they have Chinese ownership. This potentially means that products made by Chinese companies that participate in establishing facilities in the United States, or that operate in countries with which the US has a free trade agreement, would not be eligible for the subsidy.

Many automakers are watching this closely. Ford Motor Company, for example, had announced a plan to build an EV factory in Michigan in cooperation with Contemporary Amperex Technology Co. Ltd. (CATL), a Chinese-owned firm. CATL is the world's largest lithium-ion battery manufacturer for EVs, with an estimated 41 percent global market share in 2022. Under the announced deal, Ford would hold a 100 percent ownership stake in the plant and would license the lithium ferrous phosphate (LFP) battery technology from CATL, which was intended to alleviate any concerns about Chinese involvement and allow Ford to leapfrog other US companies in lithium-ion battery production. But the plant has come under the scrutiny of US government officials. Ford announced in September 2023 that it had stopped work on the facility until it can gain more clarity about the political environment.

Chinese auto manufacturers that had sought to enter the growing EV market in the United States have also pulled back on their plans. BYD, the largest EV manufacturer in the world, is a Chinese-owned company that has a North American

headquarters in Los Angeles and an electric bus manufacturing facility in Lancaster, California. After the IRA provisions were released, BYD stated that it would hold off on previously announced plans to build an EV battery factory in the United States.

Other companies hoping to benefit from the IRA credits fall into a gray area when it comes to defining ownership. For example, Envision AESC is in the process of building a $2 billion EV battery factory in Kentucky and an $810 million facility in South Carolina. The company is headquartered in Japan, but it was formed from a partnership between Automotive Energy Supply Corporation, a lithium battery manufacturer established in 2007 as a joint venture between Japanese companies Nissan NEC and Tokin Corporation, and Chinese multinational corporation Envision, which produces wind turbines and energy management software.

Concerns over the IRA's localization provisions extend far beyond the impact on Chinese technology companies. The rollout of the IRA has prompted other countries to respond with parallel green industrial policies of their own, inciting what has been called a global subsidies race.

European Union policymakers, reportedly concerned that the US legislation could adversely impact European industry and its competitiveness, issued the EU's Green Deal Industrial Plan for the Net-Zero Age in February 2023, calling for providing direct support to clean energy industries in Europe. Other green industrial policies developed around the same time as the IRA include Britain's Ten Point Plan for a Green Industrial Revolution, announced in 2020, and the 2023 Made in Canada Plan.

LEAVING DEVELOPING COUNTRIES BEHIND

Most of the future clean energy deployment needed to meet global goals for reducing greenhouse gas emissions will be in the developing world. The good news is that the necessary expansion of clean energy supply chains will create opportunities for both industrialized and developing countries to diversify away from the current reliance on China.

Achieving ambitious climate goals will require a massive scaling of clean-energy technology manufacturing. As a result, there is plenty of room for new entrants to help supply the clean energy transition. This will bring opportunities to reshape global supply chains in ways that allow both China and the rest of the world to take advantage of new markets.

But not all countries are well positioned to become competitive exporters of the same green technologies, primarily due to constraints in domestic capacity. The realities of today's global economy make it difficult for any country to create an industry on its own. Industries depend on global supply chains and international markets for both investment and demand.

Some countries will be more effective at implementing green industrial policy than others. Countries that already have proven successful at developing clean energy manufacturing industries are likely to capture more future market share. But to meet climate goals, a sizable share of future deployment of clean energy technologies will be required in economies that currently have minimal or no role in existing global supply chains.

That leaves an important role for the wealthiest nations to play in ensuring that their own green industrial policies are not achieved at the expense of poorer countries. A major omission in the IRA is a provision addressing these inequities. Tying the US green industrial policy strategy to climate finance commitments for developing countries, or even the establishment of new financing mechanisms or institutions, would go a long way toward funding and expanding manufacturing capacity and capabilities in the global South, not to mention building global goodwill.

Some developing countries have been able to establish clean energy manufacturing facilities. Kenya's Solinc, for example, locally manufactures solar panels, 80 percent of which are sold to the Kenyan market. Yet many smaller countries may not stand to benefit from adopting green industrial policies such as localization requirements, due to limited existing capacity. They may want to examine alternative strategies to procure local economic benefits from clean energy deployment, beyond local manufacturing or reshoring.

A robust installation, service, and support industry can help local economies capture much of the value associated with renewable energy projects, even if they are relying on imported technology. In addition, firms located in countries aiming to develop a renewable energy industry may consider exploring strategic technology partnerships with companies in leading markets, including joint ventures, to increase the local benefits of using foreign-sourced technology and to encourage knowledge transfer. An example of this would

be Danish wind technology company Vestas' partnerships with Casa dos Ventos in Brazil and Vibrant Energy in India.

It will take a concerted effort to develop clean energy supply chains in parts of the world that currently have no clear pathway to enter these industries through existing supply chain linkages and resource endowments, particularly in developing Africa. Given that states want to reap direct economic benefits from clean energy investments, governments in advanced industrial economies need to ensure that the fruits of the energy transition are reaching the global South.

To do so, they must pay closer attention to how green industrial policy is being implemented. There should be greater efforts to include developing countries in clean energy innovation and economic development initiatives. International dialogues, such as in the context of the Group of 20, Asia-Pacific Economic Cooperation, and other multilateral fora, can help to develop a shared vision for implementing green industrial policy that does not leave emerging and developing countries behind.

RETHINKING IN GLOBAL TERMS

The increasing adoption of green industrial policy strategies around the world is taking place within a broader global context, in which events such as the COVID-19 pandemic and the Russia–Ukraine war have fostered moves to deglobalize and to pursue national self-sufficiency in critical technology sectors. There are certainly political benefits to reframing climate mitigation policies as economic and industrial policies, especially in countries like the United States, where climate policy has long been a divisive political topic, slowing progress. But this reframing would be counterproductive if it results in policies that slow the low-carbon transition rather than accelerate it. No nation has yet convincingly articulated a vision of the future in which taking a purely nationalistic approach to climate policy and reshoring energy supply chains does not make the transition slower and more costly.

States need to take a more global look at how national policies to pursue self-sufficiency impact other countries. Instead of restricting upgrading opportunities for developing economies, advanced industrialized economies should promote reforms that enable more governments to use industrial policies to meet economic development and climate goals. They can, for example, promote constructive trade rules that allow developing countries to break into higher-value-added activities in global supply chains.

Getting green industrial policy right is critical to an energy transition that is truly global and equitable, and it may be the only way to meet urgent global climate goals. Green industrial policies can be designed to encourage the localization of clean energy manufacturing, while still fostering the competition that is crucial to further reducing the costs of those technologies and accelerating their deployment. The extent to which the United States and other countries attempt to remove themselves from global supply chains, and the pace at which they do so, should be guided by the costs and benefits of such actions—including the trade-offs that may result between incentivizing local manufacturing and accelerating global climate mitigation. ■