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Loosening the Logjam: Enabling More-Efficient Clean-Energy Finance in China

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China is at once the world's largest carbon-dioxide emitter, largest coal burner, largest manufacturer of solar panels and wind turbines, and largest consumer of solar and wind power. It is both the world's most pressing clean-energy problem and its most promising clean-energy solution. More than any other country, it is where the global fight against climate change will be won or lost. Hundreds of billions of dollars in public and private capital are being spent in China to scale up cleaner forms of energy. But, in fundamental ways, that money is being spent inefficiently. And that is a threat to global efforts to address climate change.

1: PURPOSE AND METHODOLOGY

This paper provides a preliminary assessment of the need and prospects for more-efficient clean-energy finance in China. The intent is to set the stage for a deeper analysis and dialogue between government and industry leaders in China and the United States — one that would help maximize the clean-energy bang for every buck that China is spending on clean energy, help identify where additional money is needed, and elucidate strategies to ensure that that money is spent efficiently.

The idea for this analysis grew out of "The New Solar System," a 220-page study by Stanford's Steyer-Taylor Center for Energy Policy and Finance, a joint initiative of Stanford's law and business schools. "The New Solar System," released in March 2017, lays out a framework for a more economically efficient global solar-power industry. The study analyzes how China's solar industry is changing, what those changes suggest about China's comparative advantages in the global solar industry, and what those comparative advantages suggest about policy changes the United States should undertake to help scale up solar power (1) most cost-effectively for the world and (2) in a way that provides long-term benefit to the U.S. economy and environment.[1]

Research for "The New Solar System," and Stanford Steyer-Taylor Center workshops held in the United States and China since the report's release, have involved discussions with many dozens of government officials, industry executives, financiers, and scientists in both countries who are focused on decarbonizing

the energy system. This research has underscored that improving the efficiency of Chinese clean-energy finance is a crucial and feasible next step. The research thus far has focused on the solar sector, which represents a growing but still-tiny slice of electricity generation in China.[2] In part as a result of that research, this paper focuses on intermittent renewable energy, particularly solar. But China, like the world, will reach its decarbonization goals only if it dramatically scales up a much broader basket of technologies, including energy efficiency and the cleaner burning of fossil fuels. That is why, as described below, China is investing heavily in research and development (R&D) into that full range of technologies.

The Stanford Steyer-Taylor Center's research in China has established a foundation for further work on improving the efficiency of capital flows into the broad suite of clean-energy technologies. The work has made clear that financial, and thus political, interests in the world's largest energy-consuming nation are aligning in a way that could meaningfully improve the efficiency of these clean-energy capital flows — and that thus could meaningfully expand clean-energy deployment. Such an outcome would benefit the Chinese economy, the pocketbooks of investors who understand and exploit the maturation of clean-energy finance in China, and the planet. The question explored by this introductory paper — and that could be further clarified by a next stage of research that is deeper in its finance analysis and broader in the slate of clean-energy technologies that it examines — is how to harness and hasten this shift.

The first section of this paper explores inefficiencies in the allocation of clean-energy capital in China that the government is trying to fix as part of a long-term restructuring of its electricity market. Two such inefficiencies loom particularly large:

- High levels of forced cessation of generation by wind and solar projects — a phenomenon known as "curtailment." Curtailment reduces a project's electricity sales, thus reducing profitability. The extent of curtailment in China is, say leading renewable-energy lenders in the country, a chief driver of the interest rates they charge their borrowers.
- Delays of as much as two years in the Chinese government's delivery of subsidy payments it has promised renewable-energy producers through a policy called a feed-in tariff (FIT). These subsidy payments account for one-half to two-thirds of projected revenue from typical Chinese wind or solar projects. As a result, the long delays in government FIT payments are forcing many clean-energy developers to secure additional debt to cover their original project loans. That significantly increases the cost of renewable-energy projects.

The second section of this paper delves into a problem that is not likely to be solved even if China restructures its electricity market to introduce more competition. That problem is the high cost of financing renewable-energy projects in the country — a result of the structure of China's financial system, particularly its debt markets. Here, too, China is well aware of the problem and is experimenting with solutions. Even experts in Chinese clean-energy finance, however, worry that the attempted fixes are not significant enough. This section, therefore, proposes some additional steps.

All these inefficiencies are well understood by energy insiders in China, and none of them will be solved easily. In exploring these inefficiencies, this paper aims mainly to educate investors outside China and to suggest areas for substantive dialogue and creative problem-solving between investors in China and those in the West that could meaningfully hasten the implementation of practical solutions. The Stanford Steyer-Taylor Center's research thus far has shown that leading government and industry players in both countries are eager to have that exchange and to develop workable solutions.

2. A CRUCIAL MOMENT IN CHINA'S CLEAN-ENERGY EFFORT

China is extraordinarily serious about shifting its energy system onto a cleaner path. In the first quarter of 2017, China spent $17.2 billion in public and private money on renewable energy alone. That was double the $9.4 billion that the United States spent, and fully one-third of total global investment, according to Bloomberg New Energy Finance.[3] As of the end of 2016, China had deployed a cumulative 168.7 gigawatts of wind-power capacity, about one-third of the world total and double the U.S. level, and it had deployed 77 gigawatts of solar-power capacity, about one-quarter of the world total and nearly double the U.S. level.[4] [5] In a potentially extremely significant announcement, the People's Bank of China, the country's central bank, released in August 2016 a sweeping set of guidelines intended to usher in what it described as a "green financial system," one replete with everything from anti-greenwashing standards to sophisticated carbon-finance instruments to a move by lenders to take environmental risks into account in their credit-risk assessments.[6]

Meanwhile, as noted above, China is quickly increasing its investment in R&D into a broad range of clean-energy technologies. They include not just intermittent renewables such as wind and solar, but also energy efficiency; energy storage; electric vehicles; non-intermittent renewables such as hydropower, geothermal, and bioenergy; and more-efficient ways to burn and capture carbon-dioxide emissions from natural gas and particularly from coal, which in 2016 provided 65% of the country's electricity and which is likely to remain China's most important energy source for many years to come.[7] Indeed, China's clean-energy R&D effort is a top strategic priority for the government. Evidence is mounting fast that China is advancing beyond the role of inexpensive global manufacturer that characterized the first stage of its clean-energy push more than a decade ago — and that is pursuing a level of R&D sophistication once reserved for countries such as the United States and Germany.

China also is making clean energy a cornerstone of its "Belt and Road Initiative," a massive international infrastructure-investment program that focuses on Eurasia and that is deepening China's geopolitical leadership. China has $900 billion in projects in process or planned internationally as part of the initiative, according to Fitch, the ratings agency.[8] Energy projects will be a significant part of the initiative, ranging from coal-fired power plants to renewable-energy projects to ultra-high-voltage transmission lines to transport electricity. But how well that money will be spent is a matter of mounting debate. Fitch, for instance, has raised concerns about China's Belt and Road Initiative because a large proportion of the money for the infrastructure campaign is likely to come from Chinese state-owned banks. According to Fitch, "Chinese banks do not have a track record of allocating resources efficiently at home, especially in relation to infrastructure projects."[9]

Indeed, China's domestic clean-energy push is, in fundamental ways, economically inefficient. That inefficiency stems from the government's near-total dominance over China's energy system. In renewable energy today, as in sectors from steel to cement in prior years, government control in China has produced overheated, subsidy-driven growth. The inefficiency is a mounting concern for Chinese leaders in government, financial institutions, and industry. In part to try to address it, they are moving to restructure China's electricity market to introduce more competition. They worry that, if greater economic efficiency is not brought

to China's deployment of clean-energy capital, two things will happen. China will fail to achieve ambitious clean-energy targets it has set for itself — targets far more aggressive than the already-record-setting levels the country has achieved today. And the world, by extension, will fail to achieve carbon cuts deep enough to stave off the worst effects of climate change.

Decarbonization is just one of many energy objectives that China is pursuing. During the past two decades, China has brought electricity to a massive swath of humanity. Today the country is scrambling to combat intense urban air pollution, to ensure an adequate and reliable supply of affordable energy for a growing population, and to commercialize on a massive scale a host of new energy technologies — including building the world's largest ultra-high-voltage electricity-transmission system in an effort to bring electricity, particularly renewables, from the rural parts of the country where much of it is generated to the urban centers where it will be consumed. China's use of coal still is growing, but at a slowing rate, and the country has said that coal's share of total energy consumption will fall from 62% in 2016 to 58% in 2020.[10] China also has built the world's largest hydropower plant, Three Gorges Dam; that 22.5-gigawatt facility produced more electricity in 2015 than did all of China's world-record solar capacity combined.[11] More than any other country, in short, China is pursuing an "all-of-the-above" energy strategy – the one that, for the planet, has the highest stakes.

Greater efficiency in China's clean-energy spending is particularly crucial because that spending is so massive and is expected to get significantly larger. According to the International Energy Agency, despite the large sums China is spending on clean energy, the country faces a shortfall between its total investment assets and the amount of money that it will need to spend on clean electricity and energy efficiency to do its part to prevent atmospheric concentrations of carbon dioxide from surpassing 450 parts per million (ppm), the level beyond which many scientists have warned that particularly dangerous consequences from climate change will result. China's investment assets of $4.78 trillion are dwarfed by the $6.98 trillion that it will need to spend on clean energy and energy efficiency through 2035 to help the world avoid surpassing the 450-ppm threshold, the IEA says.[12]

3: RESTRUCTURING CHINA'S ELECTRICITY MARKET

Curtailment

One significant inefficiency in renewable-energy deployment in China has been what is known as curtailment: the rejection by China's grid operators of a portion of the electricity that China's wind and solar projects generate.

In some cases, curtailment results from the fact that electricity transmission has failed to expand enough to accommodate the added power from new wind and solar installations. In other cases, it results from the fact that power demand in a given region cannot use the added power from new wind and solar installations. Curtailment tends to occur with wind projects mostly at night and with solar projects mostly in the afternoon — the times of day when the wind is blowing hardest and the sun is shining brightest.

According to China's National Energy Administration (NEA), which is responsible for much of the country's energy-deployment policy, 19.8% of potential solar-power generation was curtailed in 2016 in a handful of provinces in the northwestern part of the country in which China's wind and solar deployment is concentrated. These provinces are in rural areas located far from the population centers that need electricity and in areas where transmission

CURTAILMENT IN CHINA: STATISTICS FOR GRID-CONNECTED RENEWABLE ENERGY IN SELECTED PROVINCES IN NORTHWESTERN CHINA, 2016

	Grid-connected capacity by the end of 2016 (mw)		Cumulative energy generation in 2016 (TWh)		Full capacity operational hours in 2016		Cumulative energy curtailment in 2016 (TWh)		Curtailment rate	
Province	**Wind**	**Solar PV**	**Wind**	**Solar PV**	**Wind**	**Solar PV**	**Wind**	**Solar PV**	**Wind**	**Solar PV**
Shaanxi	2,679.00	2,784.00	2.826	1.965	1,900.00	1,459.00	0.199	0.14	6.61%	6.89%
Gansu	12,773.30	6,801.00	13.762	5.93	1,124.00	1,043.00	10.379	2.578	43.11%	30.45%
Qinghai	666.00	6,809.00	1.023	5.948	1,727.00	1,428.00	-	0.813	0%	8.33%
Ningxia	8,371.00	5,004.00	12.869	5.238	1,594.00	1,338.00	1.932	0.403	13.05%	7.15%
Xinjiang	18,798.00	5,976.00	21.984	6.635	1,558.00	974.00	13.715	3.108	38.37%	32.23%
Five-Province Total/Average	**43,287.00**	**30,374.00**	**52.464**	**28.717**	**1,424.00**	**1,151.00**	**26.225**	**7.042**	**33.34%**	**19.81%**

Note: Numbers are calculated by the China National Energy Administration and in some cases do not reflect the precise sum of the relevant column.

Source: China National Energy Administration

development has not kept pace with renewables deployment and there is little storage capacity. And even this statistic downplays the extent of the problem in certain individual provinces. In 2016, according to the NEA, 32% of the potential solar-energy generation was curtailed in Xinjiang Province, one of the provinces with the highest solar and wind production, and 30% was curtailed in Gansu, another major renewable-energy-producing province.[13] The figure above shows solar-curtailment rates in several provinces in northwestern China based on NEA statistics.

This curtailment is a colossal waste of money, particularly given that these renewable-energy projects have been bankrolled largely with a subsidy, in the form of the FIT, which is discussed below in more detail. In a thought exercise that illustrates the extent of the problem, an executive at one major state-owned renewable-energy developer in China estimated that the amount of renewable electricity curtailed in 2016 in the country was so significant that, had that power been generated and sold, it would have produced roughly $9 billion in revenue – the amount of the actual cost of the FIT in 2016.

Ultimately, China's restructuring of its electricity market, in combination with an aggressive effort underway in the country to increase long-distance power transmission, may ease renewable-energy curtailment. China last attempted to deregulate its electricity market in 2002. That reform divided the market into two grid operators, State Grid and Southern Grid, and into five large power-producing utilities. All those companies remain state-controlled. And although the 2002 reform envisioned some deregulation of electricity prices, the government continues to set those prices. One reason the 2002 reform sputtered was that China's leaders were leery of doing anything that might endanger adequate electricity supply at a time of torrid Chinese economic growth.[14] But in 2015, amid slowing economic growth, China unveiled plans for a more-extensive long-term deregulation of its power industry.

Among the long-term goals of the restructuring are opening China's retail electricity market to competition;

allowing industrial and commercial users of particularly large amounts of electricity to buy their power directly from generators or from retail electricity providers; and the prioritization of renewable-energy sources in dispatching electricity into the grid.[15] Ultimately, the reform envisions the creation of a spot power market in China — a market in which those electricity sources with the lowest marginal cost would be dispatched into the grid first.[16] These reforms remain in the very early stages in China. But their evolution — combined with China's intensifying efforts to build ultra-high-voltage transmission corridors, in large part to ferry renewable electricity from the rural areas where it is generated to the urban areas where it is consumed — could meaningfully help reduce the country's curtailment problem.

Capacity Payments

That, however, would create follow-on challenges. As the experience of countries with spot electricity markets shows, a surge in wind and solar penetration creates financial problems for producers of fossil-fueled electricity. That has intensified pressure to provide "capacity payments" to producers of fossil-fueled electricity. Capacity payments – money paid to power-plant owners in exchange for the owners' agreement to supply power when it is needed — are common around the world, particularly in deregulated electricity markets. In many countries, notably Germany, which has experienced a sharp rise in wind and solar penetration during the past decade, the scaling up of intermittent renewables has sparked calls for increased capacity payments to owners of fossil-fueled power plants. Even allowing for the likelihood that electricity-market restructuring in China, a communist country, will not follow the same path as deregulation has followed in the United States or Europe, it is realistic to expect that China too may face pressure for increased compensation to owners of fossil-fueled power plants. A February 2016 report from the U.S. National Renewable Energy laboratory highlighting the link between the rise in what it called "variable renewable energy" (VRE) and capacity payments is instructive:

> The consideration of higher VRE penetration levels with respect to capacity payments is important, because VRE can suppress energy prices while providing relatively little capacity (Felder 2011). This can impact compensation and associated incentives for new and existing conventional thermal generation3 significantly. The effect can be amplified by the existence of federal and state incentive mechanisms for renewable energy, such as renewable portfolio standards or production tax credits (PTCs) in the United States or feed-in tariffs (FITs) in other international markets.[17]

Feed-In-Tariff Payment Delays

Coupled with excessive curtailment is another significant financial inefficiency in China's renewable-energy market: delays of as much as two years in the Chinese government's payment of promised FIT revenue to wind- and solar-project developers. As of late 2016, China owed $8 billion in FIT payments.[18] Those delays are forcing many developers to take out additional debt to cover their original project loans, significantly increasing the cost of energy from these projects. As a result, some private Chinese companies that entered the renewable-energy project-development business are selling or seeking to sell their projects, having concluded that they cannot compete with state-owned companies which have bigger balance sheets and which thus can better withstand the FIT-payment delays.

Two examples, related by top executives of leading privately held Chinese solar companies, illustrate the ramifications.

One solar executive, then at a leading Chinese solar-panel maker and solar-project developer, said that, because of the large sums in FIT payments that the government owed the company, the company was

seeking to sell the Chinese solar projects it already had developed and it was focusing its efforts on developing solar projects outside China — in countries, such as the United States, where it believed it could rely on promised subsidies by governments.

The other executive, from another leading Chinese solar-panel-manufacturing firm, said the company is owed about 200 million RMB (about $30.2 million) in FIT payments. The company entered the project-development business in an effort to boost profit margins, which had grown increasingly thin in the cutthroat panel-manufacturing business. Its first 100 megawatts in solar projects were connected to the Chinese grid in early 2015. In an illustration of the outsized role that subsidies play in the profitability of renewable energy in China, the company expected to get two-thirds of its revenue for the project from the government's FIT — and only one-third from sales of actual electricity. Now, given the money it is owed by the government, the company is looking to offload its projects if it can find a buyer willing to pay enough. "We want to sell," the executive said.

In pushing some private players out of China's renewable-energy project market, the pervasive delays in government FIT payments are reinforcing the dominance of state-owned players — a result that even executives at state-owned companies say is problematic for China. "This is the situation of renewable energy in China," an executive at one large state-owned company active in renewable-energy production in China said. "It's not good."

The uncertainty over the Chinese government's payment of its FIT obligations has constrained the use of long-term power-purchase agreements (PPAs), a tool central to the growth of renewable energy in the United States and other markets. China's two state-owned grid operators typically sign PPAs with renewable-energy producers only in one-year increments, in part because the uncertainty over FIT payments makes longer-term PPAs too financially risky.

A New Market: Green Certificates

In an attempt to supplement — and, ultimately, to supplant — a national FIT fund that is groaning under the rapid growth of China's renewable-energy market, China introduced in July 2017 a new, more-market-oriented renewable-energy subsidy: financial instruments called "green certificates." Under this new system — roughly akin to the market for "renewable electricity certificates" (RECs) in the United States — a wind- or solar-power project produces one green certificate for every megawatt-hour of electricity it generates. The developer of the project then has two revenue streams: electricity, which it sells to the grid operator at the conventional-power price, and green certificates. It sells the certificates to buyers that, either for public-relations purposes or in anticipation of imminent government mandates, want to show they are supporting renewable power.

China's green-certificate market still is in its infancy. The government has not yet begun requiring coal-fired power producers to buy the certificates. And the government still is setting the certificate prices, pegging them at a discount to today's FIT payments. In 2018, however, the government is expected to begin requiring large coal-fired power producers to buy the certificates to offset every megawatt-hour of coal-fired electricity that they generate. The government also is expected to start letting the market set the certificates' prices, which likely will boost those prices. Already, the expectation of this shift is inducing leading Chinese coal-fired power producers to ramp up investments in wind and solar projects. Their goal: to produce for themselves the green certificates they will be required to have, on the theory that they can generate them in-house at a cost lower than the price they are likely to have to pay to buy them in the future on the open market.

The Chinese government's goal is gradually to phase out the FIT payments and replace them with the green-certificate market. "They're really trying to control and manage this," said a person involved in the design of

the new market. That market, this person explained, "is going to come in slowly, because they don't want to shock the system."

Moody's, the rating agency, predicts that China's green-certificate program "will support the development of the renewable energy sector in the longer term" by reducing both FIT costs and curtailment rates.[19]

Fixing delays in the payment of subsidies to renewable-energy developers would help trim renewable-energy costs in China, because it would lead banks to lower the interest rates they charge borrowers and/or to give borrowers more time to repay the loans.

4: REDUCING DEBT COSTS THROUGH FINANCIAL INNOVATION

Even if China fixed its curtailment problem and its subsidy-payment delays, it still would have a significant challenge in scaling up renewable energy: a debt market that tends to drive up borrowing costs because it is dominated by a handful of state-owned banks with an often-conservative outlook on lending.

Banks dominate the provision of clean-energy debt in China. In 2016, approximately 80% of the money lent in China for solar-power projects came from banks — as opposed, for instance, to debt that comes in the form of bonds issued by institutional investors.[20]

Inefficiency of Chinese State-Owned Banks

The dominance of clean-energy project lending in China by state-owned banks raises borrowing costs for Chinese clean-energy projects in two ways.

First, in the loans they provide, Chinese banks commonly charge significantly higher interest rates to private companies than to state-owned firms. That has the effect of preserving the market dominance of state-owned companies. And those firms, according to their own officials, tend to be less efficient in running clean-energy projects than their private competitors.

The benchmark one-year rate set by the PBOC is 4.35%.[21] The rate for longer-term debt is somewhat higher and depends on the length of the loan. In practice, when financing clean-energy projects, state-owned companies typically can borrow at roughly 10% below the relevant PBOC rate. Large private companies with balance sheets similar to those of the state-owned firms typically pay roughly 10% above the relevant PBOC rate. And smaller private firms can face significantly higher interest rates — rates double or more the relevant PBOC benchmark rate.

Executives of private clean-energy companies in China say this difference is a significant impediment for them — thus reducing competition in the clean-energy market. "The reason the state-owned firms will dominate this is that they have access to low-cost capital," said the executive then at the company seeking to sell projects in China and focus on those abroad.

Executives at state-owned energy firms agree they have an advantage — and that their advantage is a problem for China. Consider the example of one of China's five leading state-owned power generators. According to an executive at this company who is knowledgeable about the company's development of renewable-energy projects, the company typically pays 4.8% interest for a five-year loan to finance renewable-energy projects. But a private company with a financial status similar to this one typically pays 6.8% — two percentage points, or some 40%, more than this state-owned firm. Some private renewable-energy developers in China — even prominent ones that operate internationally — pay 8% or more.

This advantage accorded firms like this state-owned corporation through preferential treatment from China's banks presents a challenge for China, this executive said, because state-owned firms tend to have higher non-financial costs than private firms do. "There is a problem. The innovative power in a state-owned company is less than in a private company," the

executive said. For example, "we can't fire workers even if a [power] plant isn't profitable."

The second way that Chinese state-owned banks' dominance of Chinese clean-energy project lending raises costs has to do with the conservatism of the debt structures that many of these banks employ. In the United States, clean-energy projects often are financed through "non-recourse" debt, in which, if the borrower defaults, the lender can seize only profits from the project — not any of the borrower's other assets. Non-recourse debt tends to advantage new competitors in a market — companies that have not amassed large or healthy balance sheets. In China, state-owned banks commonly provide non-recourse debt to state-owned firms, even to those firms with poor balance sheets, reasoning that, if the state-owned borrower defaults, the government will turn over the project to the government bank. Private firms, by contrast, lack that government relationship and typically have to use their balance sheet as collateral to get loans. This compounds the advantage that state-owned firms have in getting lower-cost debt.

"There is a double standard," said the executive mentioned above from a leading private Chinese solar company. If you're a state-owned company applying to a bank for debt, "you get what you want." If you're a private company, "you're judged on your book," meaning the company's underlying financial strength.

One potential way to expand the provision of non-recourse financing in China would be to increase lending in the country by non-Chinese financiers accustomed to providing more non-recourse debt in their home markets.

Involvement in China's clean-energy market by U.S. investors has been largely limited thus far to equity investments in projects and to the facilitation of corporate public-stock offerings. The Chinese government has, as a matter of policy, said that it encourages increased foreign capital in the country – and, as detailed in the next section of this paper, the government recently has prominently reiterated that goal. However, impediments to more involvement in China by foreign lenders abound. One is a legal system that, at this point in its development, does not allow a foreign lender to seize borrowers' Chinese assets as collateral in the event that Chinese borrowers default. Another is foreign-currency risk, which from the perspective of foreign lenders is intensifying as the Chinese renminbi (RMB) declines against the U.S. dollar.[22] [23] (The RMB has regained much of the ground it lost in early October 2017, but it remains below its year-ago level.)

China's Sweeping New Green-Finance Guidelines

In August 2016, the PBOC reiterated the country's desire to attract foreign capital, particularly to invest in Chinese renewable energy. That declaration came as part of a potentially very significant announcement of a broad range of economic and fiscal steps that China intends to take to "establish a green financial system."[24]

It will remain unclear for some time whether the document, "Guidelines for Establishing the Green Financial System," is merely aspirational rhetoric or represents serious and specific directives to, as the document says, "promote the sustainable development of the economy." But the signatories are some of the major players in economic policy in China, including the PBOC, the Ministry of Finance, the National Development and Reform Commission, the Ministry of Environmental Protection, the China Banking Regulatory Commission, the China Securities Regulatory Commission, and the China Insurance Regulatory Commission.[25] And many of the recommendations are quite specific. Both those facts suggest that, if China does not follow through with the suggestions, top officials will have to justify that failure.

The guidelines articulate a national goal "to mobilize and incentivize more social (private) capital to invest

in green industries, and to more effectively control investments in polluting projects." This shift, according to the guidelines, will involve "the internalization of environmental externalities by appropriate incentives and restraints" promulgated through changes in Chinese law and policy. These sweeteners include "specialized guarantees and credit-enhancement mechanisms" to reduce the interest rates that banks charge for debt for environmentally oriented projects such as renewable energy.[26] The box below lists several of the priorities that the guidelines articulate.[27]

CHINA'S GREEN-FINANCE GOALS
Priorities issued by the People's Bank of China

- Innovation: "more innovations by financial institutions and financial markets in developing new financial instruments and services"
- Standards: the establishment of rigorous standards to determine which projects are environmentally beneficial and which amount merely, as the document puts it, to "green washing"
- Pricing: the removal of "unreasonable charges to reduce the cost of green loans"
- Risk assessment: the shift by "banks and other financial institutions to treat environmental and social risks as important drivers in their stress tests for credit risks"
- Risk assessment: the enhancement of "the analytical capabilities of institutional investors on environmental risks and [the] carbon intensity of their investments"
- Innovation: the development of a broad range of carbon-finance instruments, including "carbon forwards, carbon swaps, carbon options, carbon leases, carbon bonds, carbon asset-backed securities, carbon funds and other carbon-finance products and derivatives"
- Foreign investment: and efforts to "guide foreign capital to invest in China's domestic green bonds, green equities and other green financial products."

Source: People's Bank of China

More involvement by non-Chinese lenders in the Chinese clean-energy market could do more than reduce the cost of traditional corporate loans. It could expand debt offerings beyond those loans to include a range of instruments that thus far have been less common in China than elsewhere, including securitized debt, in which an issuer combines a variety of debt issuances into a new financial instrument that it then sells to investors, spreading risk and boosting liquidity. Securitized debt is part of a class of investments known as "structured financing."

"We need more-sophisticated investors: banks with structured-financing ability," said one veteran Chinese investment banker with experience in the clean-energy sector. "Not just plain loans."

Loan Guarantees

One tool that could help drive down the cost of debt for renewable-energy projects in China is a nationwide government loan-guarantee program. Clean-energy loan guarantees have been used widely in the United States, notably in the wake of the 2008 financial crisis. In China, they have been used in a series of pilot projects, notably over the past year in a handful of commercial-rooftop solar projects in Shanghai financed by the Bank of Shanghai and the Shanghai branch of the Bank of Beijing.[28]

Now, China is considering creating a nationwide clean-energy loan-guarantee fund. A nationwide clean-energy loan-guarantee program in China could help woo non-bank financiers — notably pension funds and insurance companies — to provide clean-energy debt, according to a senior official who oversees renewable-energy policy at China's NEA.[29] Thus far, those institutional investors are largely sitting out the clean-energy market in China, in contrast to the situation in the United States and Europe, where they are increasingly active. Broadening the pool of debt providers in China

to include these institutional players likely would drive down the interest rates charged for these loans.

5. NEXT RESEARCH STEPS

As it has been for years, the pace, breadth, and depth of electricity-market restructuring in China remains unclear. As those questions are clarified, so too will be the places where Stanford research could help inform the restructuring effort.

Where additional Stanford research is likely to help right now is in the field of Chinese financial innovation. Over the past three years, in work on China's renewable-energy industry that culminated in the release earlier this year of The New Solar System, the Stanford Steyer-Taylor Center has developed contacts with an extensive group of influential leaders in China's clean-energy enterprise. That includes high-ranking officials in such government entities as the NEA, the National Development and Reform Commission, and the Ministry of Industry and Information Technology. It includes leading executives at China's major state-owned power producers and privately held renewable-energy firms. And it includes scientists in the country's top universities and energy-focused research institutes. Many of these officials, executives, and scientists have made clear that they would welcome the Stanford Steyer-Taylor Center's analytical work, best-practice insight, and role as a platform for international dialogue in the attempt to improve the efficiency of clean-energy finance in China.

The green-finance guidelines announced by the PBOC in 2016 present a particularly timely and important field for further research. If these guidelines translated into action, they could have a sweeping impact on clean-energy finance in China — and, by extension, on the world's decarbonization effort. Some of the officials helping to shape the guidelines have contributed to Stanford Steyer-Taylor Center Research thus far. Further Stanford work could supplement study by universities and institutes in China on how to implement the policies and tools that the guidelines envision. The effort, highlighted in the guidelines, to increase foreign investment in China's green-finance products is an area in which Stanford research could prove particularly helpful. Stanford already has facilitated dialogues between investors in China and those in the United States as part of the research it has conducted thus far.

Stanford research also could help inform the creation of an effective nationwide loan-guarantee program in China for clean-energy projects — a step that has particular promise as a tool to reduce financing costs. The U.S. experience with clean-energy loan guarantees — its difficulties as well as its successes — is especially instructive for China. Stanford researchers have had extensive experience with the U.S. loan-guarantee program.[30] Applying the U.S. lessons to the Chinese context is an important area of further research.

6. CONCLUSION

Identifying and helping to resolve the key inefficiencies in clean-energy investment in China would have major implications for the world's effort to address climate change. China's NEA has said that the country plans to spend more than $360 billion through 2020 expanding renewable-energy sources such as wind and solar power.[31] Improving the efficiency of that investment could significantly increase the amount of clean energy that that investment buys. Now is a particularly opportune time to undertake this work, as high-level Chinese government and industry officials have expressed keen interest in working with Stanford to find new ways to improve the efficiency of Chinese clean-energy finance.

China not only is the globe's most important clean-energy market; it also is at a critical stage in that market's maturation. Whether China succeeds in improving the economic efficiency of its unprecedented clean-energy effort will do much to determine whether the world succeeds in decarbonizing its energy system enough to meaningfully curb climate change.

ENDNOTES

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