THE OXFORD INSTITUTE FOR ENERGY STUDIES

October 2023

Three years on:

Assessing power sector and renewable energy manufacturing policy in China since the announcement of dual carbon goals

OIES Paper: CE10

Herbert Crowther, Analyst, Energy/Climate/Resources, Eurasia Group

ISBN 978-1-78467-219-5

Acknowledgement

This project began during my time at Tsinghua University as a Schwarzman Scholar, where my principal gratitude is to David Sandalow. David was instrumental in refining the focus of this paper, reading drafts, and connecting me with many of the best analysts of Chinese energy/climate policy. There are too many of these analysts to include here, but some of those whose thoughts most helped me formulate this analysis include Jiahai Yuan, David Fishman, Lauri Myllyvirta, Cory Combs, Yan Qin, Kevin Tu, and Dimitri de Boer. The team at the Oxford Institute for Energy Studies were likewise crucial in realizing this project, particularly Michal Meidan, Anders Hove, and Philip Andrews-Speed. Their comments and suggestions improved this paper immensely, and their scholarship inspired much of this analysis.

Executive summary

Since the setting of "Shuangtan" (dual carbon) goals in September 2020, China has taken significant steps in both power sector policy and renewable energy manufacturing policy. These policy areas are key enablers for China to successfully reach its Shuangtan goals: peak CO_2 emissions by 2030, and carbon neutrality by 2060.

In the power sector, several policy priorities that made tepid progress pre-Shuangtan have experienced meaningful post-Shuangtan breakthroughs. These include progress on power market liberalization, provincial-level renewable portfolio standards (RPS), policies to accelerate distributed renewable installations, and entrenched rhetoric about building a "new energy system". The acceleration of these policy actions after 2020 suggests that Shuangtan provided a stronger political imperative for power sector reform than what existed before Shuangtan. This will ultimately make the decarbonization path of China's power sector more feasible.

For renewable energy manufacturing policy, China's existing industrial policy playbook for green industries has deepened since Shuangtan. Local governments have expanded support for local green manufacturing champions, while the inclusion of renewable energy manufacturing in "high-quality development" metrics has pushed more provinces (particularly Western and Northern provinces) to prioritize renewable energy manufacturing in local planning. For local governments, there is little ambiguity that green sectors are seen as a desirable development path by the central government – particularly post-Shuangtan.

Energy security concerns in 2021 and 2022 have complicated China's path towards Shuangtan goals, particularly due to expanded coal permitting in 2022 and 2023. However, post-Shuangtan developments in grid flexibility, power market liberalization, and green manufacturing will likely outweigh the impacts of coal capacity expansions in terms of long-term Shuangtan implementation.

As a result, Shuangtan likely represented a "critical juncture" in power sector policy, but *not* in renewable energy manufacturing policy. The speed and quantity of Shuangtan-related policy changes since 2020, meanwhile, indicate that Shuangtan has long-term staying power in Chinese energy/climate policy.

While Shuangtan priorities have survived the energy security and economic growth disruptions of 2021/2022, there is equally no indication that China is considering accelerating Shuangtan targets (to bring forward 2030 peaking or 2060 net-zero). Going forward, this may become a point of increasing external attention.

Contents

Figures

Tables

Introduction

On 22 September 2020, Chinese President Xi Jinping announced that China would reach peak carbon dioxide (CO_2) emissions by 2030, and net-zero greenhouse gas emissions by 2060. This goal, known as "Shuangtan" ("Dual Carbon" in Chinese), remains China's most important environmental pledge. It committed China to reaching net-zero emissions for the first time ever, cemented Xi's personal political emphasis on environmental issues, and helped push other large economies into similar net-zero pledges soon thereafter. In the time since its announcement, Shuangtan-related rhetoric has become a mainstay of Chinese policy documents on energy/climate issues, as well as the long-term goal for local governments to orient their energy/climate policy decisions around.

China's initial Shuangtan announcement in 2020, however, contained few details. In fact, the unveiling of Shuangtan was just one part of a wide-ranging speech by Xi to the United Nations General Assembly (UNGA). That speech provided little beyond the headline 30/60 goals, leaving the specifics of Shuangtan implementation to future elaboration by relevant parts of the Chinese government system. While the net-zero pledges of many other economies are similarly vague in their exact roadmaps to implementation, more specific guidance on how the headline goal should be implemented at the local level is especially important in the Chinese context. Indeed, how Shuangtan would be reflected in the 14th Five Year Plan (FYP), scheduled to be released just a few months after Shuangtan's announcement, was immediately identified by some analysts as a key first watchpoint for Shuangtan's importance.[1] Three years later, Shuangtan's impact on Chinese energy/climate policy is still emerging.

This paper seeks to evaluate the policy changes brought by Shuangtan on two specific components of Chinese energy/climate policy: power sector policy, and renewable energy manufacturing policy. Power sector policies analyzed here include distributed renewable generation, power market liberalization, and other initiatives to improve market-oriented green energy consumption. Renewable energy manufacturing policy focuses on the local government support enjoyed by Chinese renewables manufacturers, and the manufacturers' growing international ambitions.

This two-pronged approach is inspired by the "hardware and software" framework for Chinese energy policy first proposed by Michal Meidan, Anders Hove, and Philip Andrews-Speed, where hardware concerns the physical and capital infrastructure of the energy transition, and software focuses on the institutional and social factors driving energy policy.[2] This analysis presents a variation of the hardware/software framework, specifically focusing on power sector policy and renewable manufacturing policy as relevant to both.

Although these two areas do not cover the entirety of Chinese energy/climate policy, they are important indicators of China's decarbonization strategy, and fit neatly within the software/hardware framework. The power sector is responsible for almost half of Chinese CO_2 emissions today. Its decarbonization is essential in meeting Shuangtan targets, but power sector policy, representing the software of China's energy transition, is among the most complicated and contentious areas of political tradeoffs in China's energy and climate space. Reforms in the power sector require a balance (and tradeoffs) between market forces and the role of incumbent state-owned actors. It also requires coordination between different stakeholders, sectors, provinces, and levels of government. Meanwhile, on the hardware side, renewable energy manufacturing policy sheds light on how local governments view the economic opportunity provided by Shuangtan goals. The policy levers behind Chinese renewable energy manufacturing are an essential element in China's ability to meet its renewable energy deployment targets, and in making green industries a key component of China's future growth model. Taken together, Shuangtan targets would be almost impossible to fulfill *without* ambitious policy action in the power sector and the industrial advantages of renewable energy manufacturing. As such, these two areas are necessary components towards Shuangtan implementation—even if they do not encompass the totality of Shuangtan pledges.

---

[1] Myllyvirta (2020)
[2] Meidan *et al.* (2021)

In evaluating these dimensions of post-2020 Shuangtan implementation, this paper seeks to address the following questions: (1) Since Shuangtan, what have been the most important developments in power sector policy and renewable energy manufacturing policy? (2) To what extent do these policy changes differ from pre-Shuangtan policies, suggesting Shuangtan as a critical juncture in Chinese energy/climate policy? (3) How have energy security fears in 2021 and 2022 impacted the power sector's clean energy transition? (4) What do these changes say about the degree of policy signal sent by Shuangtan to the Chinese energy and climate policy ecosystem more broadly? (5) What does the trajectory of energy/climate policy change since 2020 indicate about China's path towards Shuangtan goals?

With all these questions, proving the exact causality between Shuangtan and specific policy actions is difficult. This paper considers both policy actions enacted for the first time after Shuangtan, as well as areas of policy concern which pre-date Shuangtan but which have seen significant momentum post-Shuangtan (power sector liberalization, for example). Given the political value of associating policy actions with Shuangtan and other central-level goals, it is possible that some of these policy actions were planned before Shuangtan, and were only later reframed to be explicitly related to Shuangtan targets. As with all sensitive areas of Chinese policymaking, this opacity of policy decision making is inevitable.

Nonetheless, by analyzing these relevant policy issues in depth, a more informed picture of Shuangtan's impact is presented. In the power sector (section 2), several components of software policy changes suggest close linkages to Shuangtan, with multiple planks of post-Shuangtan policy changes reinforcing one another. In renewable energy manufacturing (section 3), causal links to Shuangtan are less apparent. Rather, market forces and high-level political rhetoric have contributed to a deepening of longstanding renewable energy manufacturing policies in China.

This paper is composed of four main sections. The first provides further detail on the historical significance of the Shuangtan pledge, and elaborates on the most important pre-Shuangtan eras of Chinese energy/climate policy. The main analysis then follows, first with a consideration of policy changes in the power sector since 2020, and then with a discussion of policy support for renewable energy manufacturers. Lastly, it offers conclusions on what these policy changes say about the significance of Shuangtan today, the software/hardware framework, and what they are likely to mean going forward.

1. Shuangtan background

Shuangtan began as a single pledge by Chinese President Xi Jinping at the UNGA in September 2020. In Xi's four-point speech, Shuangtan is only the third item, with Xi stating that China would "have CO_2 emissions peak before 2030 and achieve carbon neutrality before 2060".[3] Beyond this pledge, there was little initial elaboration on the implications of Shuangtan. In March 2021, the National Development and Reform Commission (NDRC) for the first time unveiled the "1+N" policy framework for ensuring Shuangtan implementation, with 1 referring to the overall guidance of carbon peaking and neutrality, and N referring to a suite of other plans, including sectoral decarbonization plans and other supportive policy actions.[4] In July 2021, Chinese climate envoy Xie Zhenhua listed 10 priorities related to policy actions that fall under the 1+N umbrella, from promoting industrial upgrading to developing a circular economy and establishing a fuller green financial system.[5] Xi confirmed the 1+N framework in his October address to the opening of the COP15 biodiversity conference in Kunming.[6] Even in 2022, however, many analysts were still in the process of defining what policy steps fall under the 1+N guidance (and Shuangtan more broadly).[7]

[3] Xi Jinping (2020).
[4] De Boer and Fan (2022).
[5] CC China (2021).
[6] MEE (2021).
[7] De Boer and Fan (2022).

Reactions to Shuangtan from Chinese energy/climate policy analysts help provide more context for its initial importance. To the announcement itself, one common reaction was surprise: Chinese policy actions earlier in 2020 had shown few signs of decarbonization ambition, and the UNGA was an unexpected venue for such an announcement. Varun Sivaram, former Senior Advisor to the US Special Presidential Envoy for Climate John Kerry, commented two weeks later that China accomplishing its Shuangtan goals would be "the most Herculean thing accomplished in human history".[8] Others noted that before the details of implementation became clear, Shuangtan's signal in and of itself would be important for all levels of Chinese policymaking.[9] Analysts Philip Andrews-Speed, Sufang Zhang, and Chao Wang asserted that "while the preceding policies [2020 policy actions *before* October's Shuangtan announcement] did not reflect a critical juncture, the President's bold call may do so".[10]

As already noted, one of the earliest policy documents where Shuangtan could have made a visible policy impact was the 14th FYP, finalized in March 2021.[11] While the Shuangtan targets are mentioned in the 14th FYP, they do not feature prominently (likely due to the long FYP drafting process being underway long before September 2020).[12] The 2022 14th FYP for a Modern Energy System makes more explicit reference to Shuangtan goals, but leaves the high-level energy consumption targets unchanged from the March 2021 FYP outline.[13] On both counts, most outside observers found the energy and carbon metrics in the overall 14th FYP, and the 14th FYP for a Modern Energy System, more reflective of existing trends rather than new ambitions related to Shuangtan targets.[14] If anything, the change of title in the energy-related FYP to a "Modern Energy System" rather than a "Plan for Energy Development" was an important indicator of a potential shift in thinking more broadly, with the plan including fewer numerical targets and reflecting a broader understanding of the challenges presented by the energy transition.

Other data points indicated early uptake of Shuangtan and 1+N priorities in 2021 and 2022. In May 2021, a Leading Working Group for Carbon Peaking and Neutrality was formed under then-Standing Committee member Han Zheng, dedicated to implementing the "major strategic decision" of Shuangtan.[15] "Carbon peaking and neutrality"—a key Shuangtan refrain—quickly emerged to become the most repeated environmental phrase in key Chinese policy documents.[16] By July 2022, 11 provinces and cities had published their own roadmaps for Shuangtan goals.[17] And by 2023, on all levels of government, there were almost 200 1+N related-documents, with the NDRC authoring over 20 documents and regional governments contributing over 150.[18] The focus of both local governments and the central government on Shuangtan-related policies suggests that Shuangtan has already achieved an important role in Chinese energy/climate policy orientation.

1.1 2000s and 2010s: Differing green policy orientations

Another important condition for evaluating Shuangtan's impact on Chinese energy/climate policy is how post-Shuangtan policy actions are different from, or similar to, their pre-Shuangtan predecessors. To do this, it is helpful to characterize the most important elements of pre-Shuangtan energy/climate policy in China, particularly in terms of power sector policy and renewable energy manufacturing policy.

The past 20 years of energy/climate policy can be broken broadly into two periods. The first period is the 2000s, when China prioritized industrial incentives for renewable energy manufacturing to meet export demand. The second period is the 2010s, when policymakers pivoted to place more emphasis on domestic consumption of renewable energy. Understanding these two periods is essential for

[8] Pontecorvo (2020).
[9] Meidan (2020).
[10] Andrews-Speed *et al.* (2020).
[11] Xinhua News Agency (2021a).
[12] Hongqiao Liu *et al.* (2021).
[13] NDRC (2022b).
[14] Carbon Brief (2022).
[15] Xinhua News Agency (2021b).
[16] Zhou *et al.* (2022).
[17] IEA (2023).
[18] Sohu.com (2023).

contextualizing post-Shuangtan developments in both the power sector and the renewable energy manufacturing sector.

In the early 2000s, China's renewable energy ambitions took their first major strides, particularly centred on renewable energy manufacturing. While its domestic targets for renewable energy *consumption* remained nascent, China began laying the groundwork for the policy ecosystem that would help Chinese renewable manufacturers reach global dominance. Put differently, China's renewable manufacturing ambitions were the result of an industrial policy rather than a climate policy. The most prominent example of this is China's policy support for its solar photovoltaic (PV) industry. Despite Chinese domestic solar demand in this period being weak, subsidy programmes in foreign markets like Germany and Spain created export opportunities for Chinese manufacturers. By 2008, 90–95 per cent of Chinese solar production was directed for export to Europe or North America.[19] Even without domestic demand playing a significant role, these export markets helped Chinese solar manufacturers rise from a marginal share of global solar manufacturing in the early 2000s to dominating global solar production by the early 2010s, and continuing to the present.

Central and local policy were essential in enabling this first renewable manufacturing boom. China's incentives for solar PV development in the early 2000s, for example, were wide-ranging and robust: they included attractive access to capital from Chinese financial institutions, rapid permitting timelines for production facilities, national funding mechanisms for research and development, and tax benefits.[20] State research facilities designed to drive renewable innovation were co-located with some renewable energy firms, for example state key labs located at Trina Solar's facilities in Changzhou, and Yingli's facilities in Baoding.[21] Government incentives were important in reducing the costs of silicon and polysilicon in the supply chains of Chinese manufacturers.[22] Local governments were also crucial in pushing this process forward. For solar PV, local governments assisted solar firms with direct payments, land procurement, expedited environmental reviews, and utility agreements.[23]

Chinese wind manufacturers enjoyed similar support, with the development of China's wind industry in the 2000s defined by local content requirements (LCRs) aimed at pairing Chinese wind projects with industrial buildouts. By 2007, meeting LCRs would account for over 30 per cent of the selection criteria for public wind tenders in China, with most LCRs after 2004 requiring that at least 70 per cent of wind components be sourced from Chinese suppliers.[24] China also prioritized foreign technology transfer to improve its industrial capacity in wind manufacturing, which it did by making Chinese joint-venture ownership necessary for additional financial incentives and by making Chinese patent requests necessary for public research and development funding.[25] The result of these LCRs and policy incentives saw China's wind industry transition from being dominated by foreign firms to being dominated by domestic firms, leading to the robust industrial strength of China's wind sector that still exists today.

After the global financial crisis in 2008, however, Chinese policy support was forced to pivot towards the domestic consumption of renewables: in the export markets that first drove Chinese renewable manufacturers, the financial crisis forced renewable subsidies to be rolled back. And several of these markets began placing restrictions on Chinese renewable imports that still exist today.[26] With an expanding production capacity that already led the world by 2009, this reality left China with little choice but to find more outlets in the domestic market. Jiangsu was a clear example of this, implementing China's first solar-specific feed-in tariff (FIT) in 2009 to help drive local demand needed by Jiangsu solar manufacturers (some of which remain today as some of China's largest solar firms).[27] Robust support for domestic solar installations on a national level also began in 2009 through the Golden Sun and Solar

[19] Sufang Zhang and Yongxiu He (2013).
[20] Chen Gang (2015).
[21] Ball *et al.* (2017).
[22] Sivaram (2018).
[23] Corwin and Johnson (2019).
[24] Kuntze and Moerenhout (2013).
[25] Hayashi (2020).
[26] Yu Chen (2015).
[27] Yang *et al.* (2022).

Roofs programmes, which provided direct subsidies for solar installations and covered the costs of larger solar projects.[28] Growing policymaker emphasis on addressing air quality concerns is likewise cited as a reason for the higher urgency for domestic renewable buildouts in this period, including the start of the Air Pollution Prevention and Control Action Plan in 2013.[29] In 2011, China established a national FIT for solar generators, leading to a surge of solar installations, while the establishment of a FIT for wind power in 2009 helped wind capacity triple from 25 GW in 2009 to 75 GW in 2012.

This growing emphasis on domestic renewable consumption also helped push power sector reform to the top of the agenda in the 2010s. In terms of power sector reform, the major change of the 2010s was the rhetorical shift towards market liberalization in the power sector, with the first signs of this transition coming with the communique of the Third Plenary Session of the Chinese Communist Party (CPC) Central Committee in 2013.[30] The CPC communique's call for a more "decisive role" for markets was followed in 2014 by Xi Jinping's "energy revolution" speech, which similarly called for electricity market reform and promotion of renewables.[31] In foreign engagements, more signals came after 2008: China's commitments at the 2009 Copenhagen Climate Conference to cut energy intensity of GDP, the launching of the "ecological civilization" concept at the 2013 Third Plenary session, and the 2014 US–China joint statement on climate action.[32] This combination of high-level statements ultimately translated into the 2015 adoption of "Opinions on Further Deepening the Reform of the Electric Power System" (Document No. 9), which called for a system-wide prioritization of market reforms in the power sector, including a re-evaluation of the traditional administratively-determined electricity pricing system.[33] At the time of Document No. 9, however, promoting renewables was only one part of the upside of market reform in the power sector, with renewable energy mentioned only in passing. These statements were paired with rhetoric on renewables as the foundation of the energy system, with the National Energy Administration (NEA) stating in 2017 that "the future of coal power is to provide dispatching auxiliary service for the renewable energy industry and to make space for renewable energy generation".[34] However, despite optimism that followed the publication of Document No. 9, implementation has been much more difficult. Spot markets remain in pilot trading in many areas, and are confined to a small share of the market, with most bilateral trading taking place on a monthly or annual basis that closely resembles the prior system of planned operating hours contracts between the grid company and generators.

These two periods of policy bear particular relevance to this appraisal for two reasons. First, the overarching goal of the early 2000s policies discussed here was to support new industrial sectors for *export*. They were not specifically designed to accelerate renewable deployment in China or to achieve domestic emissions reductions, which were not yet a major domestic policy priority. And despite the evolution of Chinese policy goals in the 2010s to place more value on domestic renewable consumption, the legacy of the initial 2000s policy playbook for renewable energy manufacturing can still be felt today. How this playbook is changing post-Shuangtan—particularly in terms of local government support—will offer important insight into how Chinese policymakers view Shuangtan-related industries as a future growth driver. Secondly, while important rhetorical steps on power sector reform (like Xi's "energy revolutions" speech) were taken in the 2010s, concrete policy steps afterwards were few and far between. This suggests that, at least in the 2010s, power sector reform was *not* among the most pressing domestic areas of policy reform. And even then, power sector reform may not have been specifically oriented towards increasing renewable consumption (or decreasing emissions). As such, seeing how post-Shuangtan power sector reforms have accelerated and incorporated more focus on renewable deployment will shed light on how Shuangtan has helped power sector reform achieve a more prominent place among Chinese policy priorities.

---

[28] Sufang Zhang and Yongxiu He (2013).
[29] Xi Lu *et al.* (2020).
[30] Hove (2023a).
[31] People's Daily (2014).
[32] Xiaoli Zhao *et al.* (2016).
[33] State Council (2015).
[34] Yang *et al.* (2022).

1.2 2021 and 2022 Energy security episodes

Other than Shuangtan, the most important new pressure point for Chinese energy/climate policy since 2020 has come via power shortages in 2021 and 2022. Power shortages in 2021 were caused primarily by a mismatch between physical coal prices and the price of coal-fired electricity. Coal prices rose in 2021 as coal mining was disrupted (for different reasons) in Inner Mongolia, Shanxi, Shaanxi, and Henan.[35] But despite rising prices for physical coal, pre-set electricity tariffs did not change due to the administratively set nature of the Chinese power system. These constraints made it unprofitable for coal-fired power plants to buy and burn coal; by September, over 200 GW of coal-fired capacity was not running, equal to 20 per cent of China's total coal capacity.[36] The government issued its response to the 2021 shortages through a State Council meeting presided over by Premier Li Keqiang, with instructions to expand short-term coal capacity, improve coal transportation, and offer financial relief to coal generators. It was also Li who had stated in 2019 (pre-Shuangtan) that China should expand coal supplies and transportation infrastructure for energy security reasons.[37] But Li's 2021 message on this theme contained important elements of green rhetoric: it stressed the need to accelerate the renewable buildout, to search for new grid flexibility measures, to control high-emissions projects, and to reform electricity pricing.[38] These concerns in summer/autumn 2021 came just before the release of the NDRC's Notice No. 1439 on market-oriented reform for coal generators, a major policy discussed in detail in the following section.

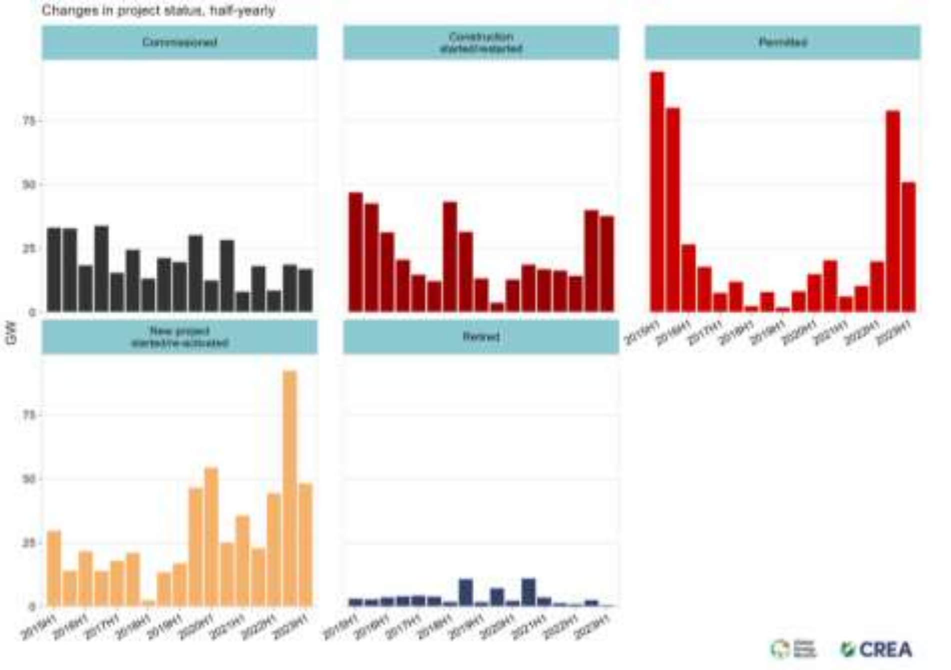
In 2022, energy security concerns returned. In March 2022, Xi debuted for the first time the phrase of "establishing the new before destroying the old" in reference to China's construction of a new energy system and its phase down of coal, a phrase that would recur to justify energy security concerns (and coal buildouts) in 2022 and 2023.[39] The 2022 power shortages were driven primarily by summer droughts reducing hydropower output, particularly in Sichuan and Yunnan.[40] These shortages coincided with record heatwaves, again creating major supply–demand imbalances and forcing power shortages. As noted by Yuan Jiahai, inflexibility in interprovincial electricity trading was a key driver of 2022 shortages, with Sichuan being unable either to reduce its pre-set electricity export agreements to other provinces, or to import electricity to make up for local electricity shortfalls.[41] The most challenging element of the 2022 shortages was their timing. They materialized just as grid planners were recovering from the 2021 shortages, forcing policymakers to double down on all possible mechanisms to promote short-term energy security. They also occurred in the aftermath of the Russian invasion of Ukraine and extreme volatility in international commodity markets, raising system-wide concerns about energy security in addition to the previous year's challenges.

In China, the primary short-term energy security response remains coal (the "old"). China approved over 100 GW of new coal-fired power plants in 2022 alone, the highest figure for Chinese coal approvals since 2015. By mid-2023, total post-2022 permitting for Chinese coal projects surpassed 150 GW, with 2022/2023 figures on actual construction starts/restarts at their highest levels since 2018/2019. This instinct prompted many commentators to assert that China's potential relapse into coal would entrench the interest of coal generators, increase stranded asset risks, and slow China's path towards Shuangtan goals.[42] Government rhetoric in 2022 on the importance of maintaining energy stability seemed to suggest as much, potentially making Shuangtan realization a more challenging task. A more explicit consideration of these coal-related changes is considered in section 2 and in the conclusion.

---

[35] Fishman (2022).
[36] Meidan and Andrews-Speed (2021).
[37] Yixiu Wu (2019).
[38] China Government Network (2021).
[39] Xinhua News Agency (2022).
[40] Anon. (2022).
[41] Zhijian Xia (2022).
[42] Xiaoying You (2023).

Figure 1: Progress of new coal power projects and retirements in China



Source: Champenois et al (2023)

2. Power sector policy

China's power sector system has long been characterized by centralized generation. Particularly before the 2010s, most provincial electricity systems were built around baseload coal-fired power plants (or baseload hydropower in a few exceptions). As part of this system, power prices were determined administratively. This centralized, price-sticky environment is not conducive to climate goals: grid planners must prioritize providing baseload generation to meet peak demand moments, with a centralized system (limited distributed generation and/or grid flexibility) inevitably relying on coal to provide that buffer. But post-Shuangtan, policy steps have been taken that lay the groundwork for changing the basis of this system. While the initial seeds of power sector reform emerged in the 2010s, Shuangtan has helped push that reform ahead on multiple verticals. The following subsections on distributed generation, power market liberalization, renewable portfolio standards, and green energy certificates represent four of these steps.

2.1 Distributed generation and grid flexibility

Movements towards more distributed renewable generation and a more flexible electricity grid are one of the most important changes to the Chinese power sector policy post-Shuangtan. In particular, since Shuangtan, distributed solar generation has come to eclipse even the importance of centralized utility-scale solar, long the main driver of Chinese renewable deployment projections. According to the International Energy Agency (IEA)'s 2021 pathway for China to reach net-zero, by 2060 China will need over 4,000 GW of solar capacity.[43] Of that, the IEA outlines 2,200 GW of distributed solar installed on buildings. Expanding distributed solar generation is especially important because a majority of China's solar installments pre-Shuangtan have been located in sparsely populated Western and Northern provinces, which then rely on complex transmission mechanisms to reach Eastern coastal demand centres. Deploying more solar in areas of higher electricity demand—the Eastern coastal provinces—will require distributed generation that follows different models than utility-scale solar.

[43] IEA (2021).

Due to their high endowments in buildings and industrial sites, these coastal provinces were already well suited to accommodating more distributed solar generation pre-Shuangtan. According to one 2021 study, Guangdong, Shandong, and Jiangsu have the highest potential for distributed solar generation in all of China.[44] The same study found that distributed solar capacity could reach 380 GW by 2030, contributing to over 30 per cent of the Chinese government's goal of 1,200 GW of total wind and solar capacity installed by 2030. Pre-Shuangtan, Jiangsu province was already exploring ways to promote distributed solar installations and to pursue power market reforms that benefited distributed generation.[45] At the time, this approach was in sharp contrast to the more traditional centralized-solar orientation of inland provinces like Inner Mongolia. But since Shuangtan, Jiangsu and other coastal provinces have been able to pursue much more aggressive policies promoting distributed generation.

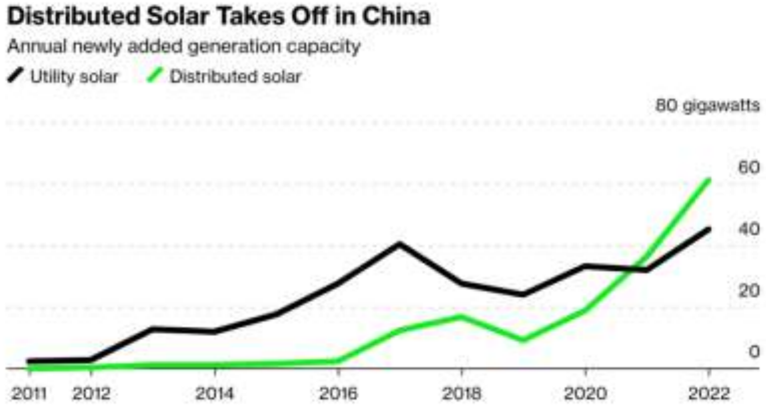
The most tangible policy driver of distributed solar generation growth post-Shuangtan has been the adoption of the whole-county solar programme in June 2021. Less than a year after the announcement of Shuangtan, the NEA published a notice for provinces to determine which county-level zones could be considered for a new policy to promote distributed solar generation.[46] Counties that could install distributed solar on at least 50 per cent of government buildings, 40 per cent of non-government public buildings, 30 per cent of commercial and industrial (C+I) buildings, and 20 per cent of residential buildings would qualify to have a single developer provide and install all of the panels.[47] The policy certainty provided by the whole-county solar programme helped lower purchase prices for residential and C+I buyers, and raised incentives for local officials to assure residential and C+I owners of how they can sell excess generation to the grid. Rising energy prices (or the threat of future rises, as discussed in the following section) likewise have pushed further interest in installations.

Since its launch in 2021, the programme has been a resounding success, with more applications arriving than central officials expected. In 2022, China installed over 60 GW of distributed solar generation, almost 20 GW more than utility-scale solar installations.[48] China's 2022 installations of 51 GW rooftop solar were almost 20 GW more than all US installed renewable capacity in 2022. This was the first year that distributed solar installations outpaced utility-scale solar installations in China: utility-level installations had been almost three times as large as distributed installations as recently as 2019. Distributed solar generation, particularly at the household level, requires more complex residential and utility policy arrangements than centralized solar. The whole-county solar programme has helped push provinces and counties to overcome those challenges, with Shuangtan likely helping provide an additional high-level push for counties to sign up for the whole-county scheme. The distributed solar programme has also attracted the attention of many of China's largest state-owned enterprises, including many not traditionally involved with renewable energy production. While this has led some commentators to criticize the fairness of contracts awarded by local governments as part of the whole-county solar programme, it signifies a growing interest from important stakeholders in the Chinese system to capitalize on Shuangtan-related opportunities.[49]

---

[44] Yu Wang *et al.* (2021).
[45] Yang *et al.* (2022).
[46] NEA (2021).
[47] Shaw (2021).
[48] Bloomberg (2023b).
[49] China Energy Network (2022).

Figure 2: Distributed versus utility-scale solar installations in China, 2011–2022



Source: Bloomberg (2023b)

The importance of the whole-county solar programme can also be seen by the provinces that have been most eager to participate in it, especially coastal provinces. Jiangsu and Shandong, for example, were among the provinces with the most initial applications to the whole-county solar pilot in 2021.[50] Less than a year after the initial NEA announcement of the whole-county scheme, Shandong officials declared that Shandong had 70 counties eligible for this distinction, with a potential distributed solar capacity of up to 30 GW.[51] Jiangsu had 59 counties apply in 2021, with Jiangsu government communications making reference to how the programme was accelerating Jiangsu's existing movement towards distributed generation: Jiangsu's distributed solar capacity increased more than 500 per cent between 2015 and 2020. In Jiangsu's 14th FYP for Renewable Energy, released in June 2022, the whole-county scheme features prominently as a vehicle for promoting the uptake of distributed solar, which should reach 15 GW by 2025.[52]

Jiangsu's framing of the whole-county solar programme states that distributed solar (rather than centralized solar) is better suited to Jiangsu's "local conditions". This explicit framing by Jiangsu and similar demand-intensive Eastern provinces is important in sending long-term signals for distributed solar generation. It also suggests that provincial planners have interpreted the impetus of Shuangtan as justification to push the decarbonization steps best suited to their provinces, even when the beginnings of those policies pre-date Shuangtan (as is the case for distributed generation in Jiangsu). Further, as prosperous provinces like Jiangsu and Shandong emphasize distributed solar more publicly and gain experience with successful integration of distributed generation to local grids, other provinces (even non-Eastern provinces) are likely to increase their distributed energy buildouts. These distributed renewable sources will provide important grid flexibility and renewable capacity for future decarbonization instruments.

Post-Shuangtan government support for distributed generation can also be seen in government and media coverage of how the whole-county solar programme is addressing rural poverty alleviation. While the legacy of using solar for rural development traces to the 1990s in China, in the NDRC's January 2022 guidance on accelerating China's low-carbon transition, an entire section is devoted to promoting rural solar buildouts.[53] Within this emphasis, grid companies should "give priority to purchasing their (rooftop distributed) generation", financial institutions should prioritize these projects, and rural collectives should together invest in renewable installations. Ruicheng county in Shanxi province is one example of a local community which has already received substantial media attention in China for the economic benefits that distributed generation has brought.[54] In the future, rural residential PV

[50] Bloomberg (2021).
[51] Shandong Province Energy Administration (2022).
[52] Jiangsu DRC (2022).
[53] NDRC (2022c).
[54] Lixin Zhu and Ruisheng Sui (2021).

deployments could even become useful in enabling greater uptake of heat pumps for winter heating, helping to address air quality issues associated with coal burning for winter heat in rural areas.[55] Linking distributed solar with the politically unassailable priority of rural poverty alleviation (and potentially local air quality) is also an important breakthrough for distributed solar, which will provide a long-term political driver for distributed solar buildouts.

In addition to the whole-county solar programme, distributed generation has also been pushed forward since 2020 by projects to support direct current (DC) buildings and districts. These DC buildings and districts mean that more distributed solar production is stored and consumed in local microgrids, without many of the complications associated with reconciling distributed generation with the broader electricity grid. As of 2022, there were already over 60 low voltage direct current (LVDC) demonstration projects in China.[56] Just like whole-county solar, the momentum behind this development is coming primarily from the Eastern demand-centre provinces. Guangdong has the most supportive policy environment and overall number of projects, while Jiangsu and Zhejiang are also in the top five. At the national level, DC projects and solar+storage are called out explicitly in the NDRC's October 2021 guidance on how to reach peak emissions by 2030, with over half of new public buildings and factories mandated to have distributed solar installations by 2025.[57] Even before this guidance was issued, a majority of DC projects in China were in C+I areas due to the higher electricity prices faced by C+I consumers. By installing more DC systems, C+I consumers can insulate themselves from future rises in transmission and distribution tariffs, which are likely inevitable as grid planners accommodate a higher penetration of renewables.[58]

This development is important in accelerating China's path towards Shuangtan in multiple key ways. Firstly, central emphasis on distributed generation rather than utility-scale generation post-Shuangtan gives Eastern provinces a new high-growth approach to expanding their renewable buildouts. As shown above, provinces like Jiangsu had already begun moving in this direction before Shuangtan. But the overall movement towards distributed generation by provinces like Zhejiang, Shandong, and even Southern demand centres like Guangdong is now unmistakable, suggesting that Shuangtan-related goals have, at the very least, emboldened them to accelerate distributed generation planning. Because the local conditions of these provinces are better suited to distributed generation than utility-scale generation, successful programmes for distributed generation will enable these provinces to use local renewables to meet a larger share of peak demand moments. These local renewables are free from the risks and costs associated with electricity imported from other provinces. The expansion of distributed energy systems with C+I consumers will also likely improve long-term grid flexibility and storage uptake (although rapid distributed installations can also pose their own challenges to short-term grid management). These factors will likely combine to help coastal provinces be more confident about meeting peak demand moments *without* the full extent of new coal buildouts on the scale first indicated in 2022/2023.

Secondly, steps by provinces like Jiangsu and Zhejiang to prioritize local distributed generation will put more pressure on renewable generators and electricity distributors in Western and Northern provinces to accelerate their efforts at dispatching renewable power to Eastern demand centres. Progress on interprovincial power trading and renewable energy transmission has been difficult since 2014, devoid of a Shuangtan-like policy push. As Eastern demand centres move forward with plans to satisfy larger shares of their energy demand with local distributed generation and grid flexibility, Western and Northern provinces will need to work harder to ensure end-markets for their renewable energy generators. Post-Shuangtan guidance on constructing a unified national power market and reducing barriers to interprovincial transmission will likewise push more urgency from Western and Northern provinces.

---

[55] Hove (2023b).
[56] Jing Kang *et al.* (2022).
[57] NDRC (2021c).
[58] Zhang and Fishman (2022).

Lastly, the policy support for distributed generation since Shuangtan is important in communicating that the traditional power system model based on centralized coal power is no longer the only path for ensuring energy security. This goes alongside stronger policymaker emphasis post-Shuangtan on the importance of building a "modern energy system", with distributed generation highlighted in the NDRC plan on building a modern energy system. Even if that system still relies on coal (the "old") today, it will eventually rely on renewables ("the new") when they are ready. Energy security and grid stability concerns have become urgent short-term priorities since 2021/2022, but distributed generation and grid flexibility form an important component of how the Chinese power sector may meet future peak demand without growth in coal consumption. In the future, the policy groundwork laid in 2021/2022 for distributed generation may be seen as a key turning point in making that possible.

2.2 Power market liberalization

Whether or not to move towards a more market-based power system has been another of the longstanding dilemmas in Chinese energy/climate policy. As mentioned earlier, the contemporary political agenda of grid liberalization can be traced back to Xi's "energy revolution" speech in 2014, with the earliest steps in power market reform dating all the way to 2002. But despite the signal sent by Xi's energy revolution speech, from 2014 until Shuangtan, sweeping progress on electricity market reform was few and far between. This is consistent with the hardware/software argument of Meidan, Hove, and Andrews-Speed, with software changes to power sector policy among the most complicated in China's energy/climate system. It is only since 2020 (Shuangtan, and also energy security fears) that power market liberalization has seen renewed vigour in policy implementation, particularly through central-level guidance on market reform and restructuring.

The two most important steps in power market liberalization since Shuangtan are the NDRC's notices 1439 and 118, which serve to adjust China's electricity pricing system and create a unified national electricity market. The NDRC released its "Notice on market-oriented reform of on-grid electricity prices for coal-fired power generation" (Notice No. 1439) in October 2021, a year after Shuangtan and immediately after power shortages that autumn. The major changes mandated by this notice were to force all coal generators to sell into wholesale electricity markets, to allow for a wider range of price fluctuations outside the pre-set coal tariff, and to force C+I customers to buy from wholesale markets instead of from coal generators at pre-set power prices.[59] As some commentators noted, this document effectively meant the end of the system of guaranteed offtake hours for coal producers, long the basis of financial security for coal plants in China.[60] The importance of this policy shift should not be understated. Guaranteed offtake hours are both the primary policy privilege enjoyed by coal generators in China, and the principal mechanism for keeping unprofitable coal generators online (especially ageing and inefficient plants). Indeed, the October announcement of Notice 1439 followed a pledge by Xi in April 2021 that China would begin "phasing down" coal consumption in the 15th FYP (from 2026), while "strictly controlling" coal consumption before then.[61]

Together, these statements helped lend crucial early credibility to Chinese claims of moving to a new energy system in the wake of Shuangtan. Removing the system of guaranteed offtake for coal producers was always going to be one of the most challenging early policy steps for Shuangtan; the twin 2021 developments of Xi's 15th FYP pledge and Notice 1439 indicate a strong link to Shuangtan guidance. Notice 1439 also bears relevance to the string of expanded coal permitting in 2021 and 2022. It suggests that even if all permitted coal plants are built, they will run as support for renewables, not as baseload power. Coal capacity may increase without coal consumption or coal emissions necessarily increasing, with Chinese coal major Shenhua stating in 2023 that newly built plants may be able to run at as little as 20 per cent capacity factor, far below historical expectations for coal plants in China.[62]

---

[59] NDRC (2021b).

[60] Fishman and Zhang (2021).

[61] Xinhuanet (2021).

[62] Bloomberg (2023c).

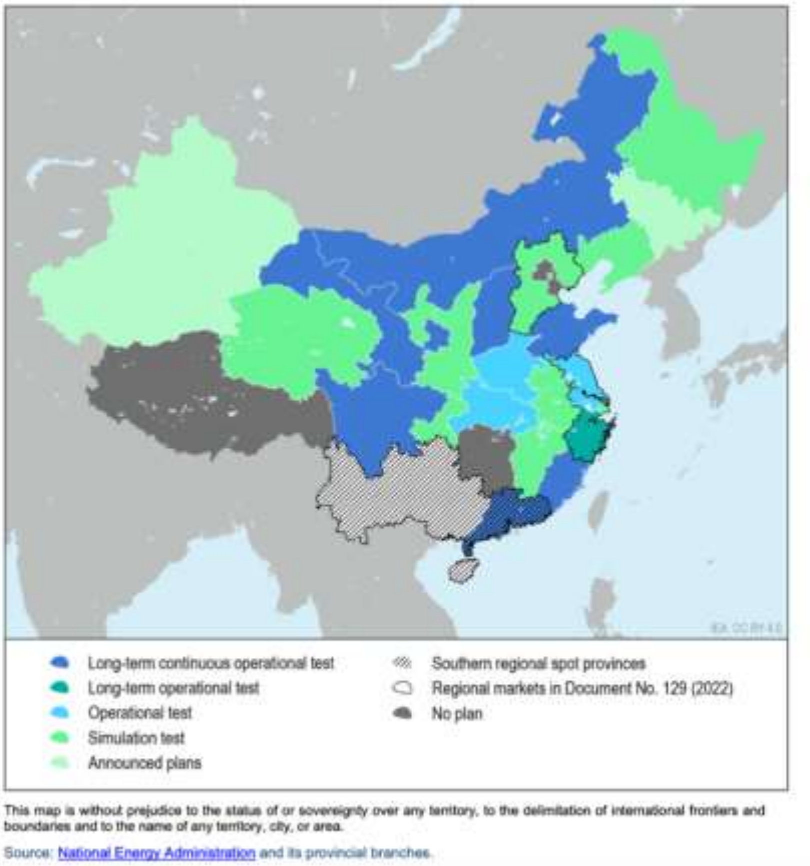
Further, by increasing the range of price fluctuation beyond the administratively set coal tariff (up to 20 per cent higher or lower than the initial tariff), Notice 1439 will push more electricity *purchasers* towards renewable generators rather than coal generators. This is because the upper band of the price range is built primarily to accommodate higher coal input prices, while the lower band will more serve renewable generators. This policy change was a concession to coal generators, as high coal input prices had made it unprofitable for coal generators to run during the energy security episodes of 2021/2022. But for electricity purchasers, it will continue to formalize the long-term price attractiveness of renewables: as domestic renewable manufacturing capacity expands and deployments continue at pace, renewable prices will fall further below the pre-set tariffs. Notice 1439's mandate for C+I consumers to purchase their own power will likewise accelerate this green purchasing process, while C+I consumers also pursue their own on-site distributed generation and storage installments.

The second major post-Shuangtan breakthrough in power market liberalization is the NDRC's "Guiding opinions on accelerating the construction of a national unified electricity market system" (Document 118). Document 118's primary pre-Shuangtan predecessor was the NDRC's 2017 guidance on electricity spot markets, which selected eight regions for early efforts in spot markets.[63] Document 118 follows up on one of the major priorities of the 14th FYP for energy, which frames liberalized power markets as a key part of building a modern energy system.[64] Released in January 2022, Document 118 sets out a goal for a preliminary national electricity market to be constructed by 2025. By 2030, a national electricity market should be "basically completed".[65] Just like Notice 1439, its issuance was likely accelerated by the energy shortages of 2021 and 2022, with one of the long-term goals of a national spot market being to reduce the risks of peak demand moments. Alongside Notice 1439, Document 118 will push forward power market liberalization in China in a number of key ways.

Firstly, Document 118 makes specific mention of integrating regional/provincial electricity markets into the broader national system. This statement will add pressure for provincial officials to take market-oriented power market reform more seriously. Provincial hesitation was one of the primary reasons for relatively slow progress on power market liberalization since its first announcement in 2014, helping explain the need for renewed top-down emphasis (and suggesting a more direct causal link with Shuangtan). Provincial pilots for spot electricity markets have been underway since 2018, with limited success. By April 2023, provinces responsible for over 80 per cent of China's total electricity consumption had at least begun spot market trials, but the permitted amounts of spot trading remained small.[66] And in September 2023, the NDRC published its first basic rules for how spot markets should be organized to play a productive role in a future unified power market.[67] Establishing firm deadlines for when provincial pilots should be compatible with a national system will reduce the risk of laggard provinces slow-rolling Shuangtan implementation, and will build the institutional policy support for expanding the role of spot trading in the future. Even if spot markets today remain at low volumes, the necessity of ensuring compatibility with other provinces in a national market will help planners view spot market reform seriously. It will also make provincial grid planners more confident that in moments of peak electricity demand, they can rely on higher prices to drive demand down and have existing generators increase production, therefore requiring less new coal capacity. This approach was implemented successfully by Guangdong (an early adopter of pilot spot markets) during summer 2022 grid crunches, when it removed the its pre-set spot market price caps, resulting in prices rising to over 30 per cent beyond the initial spot market range. This helped push more generators to produce at high volumes and discouraged marginal spot buyers. Reactions like Guangdong's reconcile the high-level decarbonization imperative provided by Shuangtan with the short-term focus on energy security, suggesting that Shuangtan is helping these provinces find a "green lining" in their response to energy security challenges (although Guangdong's coal permitting since 2022 has been the largest in China).

[63] NDRC (2017b).
[64] NDRC (2022b).
[65] NDRC (2022a).
[66] IEA (2023).
[67] NDRC (2023c).

Figure 3: Status of China's provincial pilot spot markets, 2023



Note: This map is for illustrative purposes and does not represent the expression of any opinion concerning the legal status or sovereignty of any country or territory, the delimitation of frontiers or boundaries or the names of any territory, city or region.

Source: IEA (2023)

Secondly, Document 118 makes specific mention of lowering barriers to interprovincial electricity trading. As discussed earlier, one of the primary challenges for Shuangtan is matching China's endowment for renewable generation (primarily in the West) with its demand centres (primarily in the East). Distributed generation can help reduce that imbalance, but not solve it entirely. Improving interprovincial trading, particularly for low-cost renewable generation in Western and Northern provinces, will be an equally important aspect of decarbonizing China's power system. Reducing the barriers associated with transmission across provinces was identified by the IEA as one of the primary policy steps necessary for facilitating an efficient electricity market in China in its 2023 report on Chinese electricity spot markets. Making progress on interprovincial electricity trading is also key for facilitating more efficient renewable energy consumption and reducing renewable energy curtailment. While provincial officials will still be hesitant about over-reliance on imported electricity between provinces and will want to protect local electricity generators, Document 118 places interprovincial trading in an important position of policy focus.

Taken together, these post-Shuangtan guidances from the central government will add more market-oriented elements into the power system. While implementation will still be determined on a local level, central government emphasis on this theme in 2021 and 2022 is an important follow-up to the first round of emphasis in 2014 and 2015. It is difficult to adjudicate between the relative influence that Shuangtan and energy security episodes may have had on both documents. Interestingly, these reforms appear more "market-friendly" than most other areas of Chinese policymaker scrutiny in recent years. Even as high-level guidance on other policy areas becomes more market-sceptical, in the power sector, market-based reform appears to have the political blessing of being part of "reform". The NDRC's guidance on a new energy system explicitly calls on "deepening the reform of the electric power system and accelerating the establishment and improvement of an electric power market system in which the mid and long-term market, spot market, and auxiliary service market are organically connected".[68] At least for the power market, "deepening reform" means more market-friendly changes in an era otherwise characterized by market-scepticism in Chinese policy directions.

2.3 Renewable deployment—Renewable portfolio standards

For binding policy drivers of renewable capacity consumption since 2020, the most important change has been the intensification of provincial-level renewable portfolio standards (RPS). China first announced efforts to establish an RPS system in 2019, with these plans taking on substantially more fervour post-Shuangtan.[69] In May 2020, the NDRC first issued expected guidelines of provincial RPS ranges for that calendar year, separated by renewable generation including and excluding hydropower. From 2021, the NDRC has announced RPS targets for each province *before* the next calendar year, alongside a finalized announcement of the current year's RPS table. Importantly, the RPS is a measure of renewable consumption rather than renewable deployment or renewable generation. This means provinces should not build projects that will be difficult to integrate to the grid, or that will be far from demand centres, but should instead prioritize policies to guarantee effective consumption of renewable buildouts.

While the first set of full RPS responsibilities was announced in 2020, 2021's RPS guidance conveyed stronger post-Shuangtan urgency in multiple ways. Perhaps the two most symbolic differences were the reference to "carbon peaking and neutrality" in the preamble of the text, and the announcement of current-year targets as "binding indicators", while the RPS target for the following year is an "expected indicator".[70] In 2022, RPS guidance from the NDRC placed new emphasis on transmission, stressing the need to "strictly implement the requirements for […] power transmission from West to East and interprovincial and trans-regional transmission channels".[71] The proportion of power transmitted in this way should rise every year—a rule likewise articulated in 2023 RPS guidance. Pairing RPS targets with transmission requirements is an important step towards more effective nationwide transmission (even if the primary motivation for such guidance is simply to increase utilization of existing infrastructure). It is also a departure from the 2010s, when local policymakers were more rewarded by the economic benefits of renewable buildouts than by the environmental benefits of renewable consumption. In 2023, RPS guidance added an additional key element by identifying green energy certificates (GECs) as the "main accounting method" for RPS evaluation.[72] The development of GECs is discussed in detail in the following subsection, and is another policy initiative that has received a strong post-Shuangtan push. The steady intensification of RPS rhetoric, paired with Shuangtan justifications and other post-Shuangtan policy issues, suggests that RPS implementation has benefited from the overall post-Shuangtan policy environment, even before the specific values of RPS increases are discussed.

Actual RPS ratcheting from 2020 to 2024 indicates little hesitancy by central planners about the growing role for renewables in the Chinese power system. For the first year of binding RPS implementation in 2021, for example, every province except Gansu and Xinjiang achieved its minimum stated RPS obligations. Afterwards, the NEA specifically called out this underperformance by Gansu and Xinjiang in its April 2022 discussion of the 2021 results.[73] And despite their underperformance in 2021, both Gansu's and Xinjiang's targets rose the following year. For Gansu, the target of overall renewable consumption rose from 49.5 per cent in 2021 (unachieved at 46.9 per cent) to 50 per cent in 2022, and 51.1 per cent in 2023. Xinjiang's target rose from 22 per cent in 2021 to 22.8 per cent in 2022, and 24.9 per cent in 2023 (although as of 2024 it no longer has a pre-set RPS guidance). These cases show that

---

[68] NDRC (2022b).
[69] NDRC (2019).
[70] NDRC (2021a).
[71] NDRC (2022d).
[72] NDRC (2023a).
[73] NEA (2022).

the RPS has already established itself as a key mechanism for ensuring there are no provinces slow-rolling China's energy transition. Particularly in RPS targets for 2023 and 2024, there is little room for special exceptions for any provinces *not* to meet uniform expectations for RPS increases. This indicates that on RPS policy, provinces may be less inclined to push back against central rulemaking than they have been on historical issues over power market or transmission reform.

Further, despite 2021/2022 energy security anxieties, targets set for 2022/2023 remained on forward-looking paths. The average growth in non-hydro RPS targets for provinces in 2023 was 1.33 per cent, in line with the growth from 2021 minimum RPS guidance to 2022 targets (Table 1). Even for RPS that include hydro (which should theoretically decline in 2022/2023 due to hydropower shortages in 2021/2022), RPS targets still increased by an average of 0.86 per cent from 2022 to 2023. For the hydro-dependent provinces which saw their hydro-inclusive RPS drop in 2022 (Sichuan and Yunnan), non-hydro RPS targets continued to intensify in line with all other provinces. While RPS targets may be informed primarily by existing installation capacities (or projections) by provinces, consistency in RPS ratcheting is an important signal to provinces on long-term central government commitment to renewable consumption targets. It is also relevant in the context of energy security rhetoric in 2022, that even if the "old" must provide short-term relief to the energy system, the "new" should still continue to be constructed at pace.

For 2024 RPS targets announced in August 2023, non-hydro RPS targets are even stronger: 25 of the 28 other provinces covered saw their non-hydro RPS target rise by 1.7 per cent, a step up from 2023's 1.33 per cent average growth in non-hydro RPS targets. These 2024 targets could suggest that some parts of energy security anxieties may be easing. They may also reflect that national planners see market conditions as ripe for further ambition on renewable consumption: either as the central government responding to signs of increased appetite by the provinces independently, or as the central government seeing fewer reasons for any provincial slowing of ambition. This ascending rate also indicates that, going forward, RPS standards will be important safeguards for preserving renewable energy consumption growth, regardless of external pressures.

Table 1: Growth in provincial targets for non-hydro renewable portfolio standards

Province	Goal (%)			Target increase (%)	
	2022	2023	2024	2022–2023	2023–2024
	2022 goal (non-hydro)	2023 goal (non-hydro)	2024 (non-hydro)	22 to 23 (non-hydro)	23 to 24 (non-hydro)
Anhui	15.25%	16.50%	18.20%	1.25%	1.70%
Beijing	18.75%	20.00%	21.70%	1.25%	1.70%
Chongqing	5.25%	6.50%	7.70%	1.25%	1.20%
Fujian	8.75%	10.00%	11.70%	1.25%	1.70%
Gansu	19.25%	21.50%	23.20%	2.25%	1.70%
Guangdong	6.25%	7.50%	9.20%	1.25%	1.70%
Guangxi	11.25%	12.50%	14.20%	1.25%	1.70%
Guizhou	9.75%	11.00%	12.70%	1.25%	1.70%
Hainan	9.25%	10.50%	12.20%	1.25%	1.70%
Hebei	17.25%	19.00%	20.70%	1.75%	1.70%
Heilongjiang	21.25%	22.70%	24.40%	1.45%	1.70%
Henan	19.25%	21.00%	22.70%	1.75%	1.70%
Hubei	11.25%	12.50%	14.20%	1.25%	1.70%
Hunan	14.75%	16.00%	17.70%	1.25%	1.70%
nner Mongoli	20.75%	22.00%	23.70%	1.25%	1.70%
Jiangsu	11.75%	13.00%	14.70%	1.25%	1.70%
Jiangxi	13.25%	14.50%	16.20%	1.25%	1.70%
Jilin	22.25%	23.50%	25.20%	1.25%	1.70%
Liaoning	14.75%	16.00%	17.70%	1.25%	1.70%
Ningxia	23.25%	24.50%	26.20%	1.25%	1.70%
Qinghai	25.75%	27.20%	28.90%	1.45%	1.70%
Shaanxi	16.25%	18.50%	20.20%	2.25%	1.70%
Shandong	13.75%	15.70%	17.40%	1.95%	1.70%
Shanghai	5.25%	6.40%	7.70%	1.15%	1.30%
Shanxi	20.25%	21.50%	23.20%	1.25%	1.70%
Sichuan	7.25%	8.50%	9.70%	1.25%	1.20%
Tianjin	17.25%	18.70%	20.40%	1.45%	1.70%
Xinjiang	13.75%	14.50%		0.75%	
Yunnan	16.25%	16.20%	19.20%	-0.05%	3.00%
Zhejiang	9.75%	11.00%	12.70%	1.25%	1.70%
			Yealy average:	1.33%	1.70%

Source:NDRC[74]

2.4 Renewable deployment—Green energy certificates

The development of GECs is the final power-market policy platform analyzed here to make notable positive strides since 2020. GECs are sold (or distributed) to power consumers to verify a unit of renewable energy consumption. Similar to the RPS, the work behind GECs began before Shuangtan in 2017, but GECs have only started to approach policy maturity post-Shuangtan.[75] In its earliest iteration, the GEC programme was framed as a way to reduce the fiscal burden of renewable energy incentive policies like FITs. Renewable generators, including subsidized renewable energy generators, could sell GECs in lieu of receiving subsidies like FITs. Theoretically, this would reduce the subsidy deficit faced by the Ministry of Finance in compensating power generators for green FITs, which by 2017 was already over 100 billion yuan.[76] The first version of the GEC, however, faced major challenges. Market participants did not want to pay prices equal to FITs, therefore reducing the

[74] NDRC (2021a), NDRC (2022d), NDRC (2023a)
[75] NDRC (2017a).
[76] Deting Li and Furong Jiao (2021).

incentives for power generators to offer GECs. And GECs were hard to track, raising the risks of double-counting.

Since 2020, however, the role of GECs has become more defined. Firstly, in 2021 the NDRC stated that GECs should serve as the primary registry for companies to verify independent green power purchases, and ultimately for provinces to verify use of GECs in calculating their RPS performance, confirmed by NDRC RPS guidance in August 2023.[77] In November 2022, Beijing officials published rules for 2023 GEC transactions. These included centralizing GEC transaction information under one database, and binding GEC recipients with direct purchases of power.[78] These steps reflected the need for the central government to lend higher institutional credibility to GECs. They also began to address many of the earlier issues with GECs over data quality and environmental integrity. Particularly for export-oriented industries, data integrity in GEC considerations is a key commercial priority, pushed forward since 2020 by external policies like the European Union (EU)'s Carbon Border Adjustment Mechanism.

The most decisive step towards full GEC legitimation arrived in 2023. In a set of new rules, the NDRC clarified the types of generation that can be counted by GECs, defined the purpose of GECs for RPS and other renewable accounting, and limited the tradability of GECs.[79] These changes responded to frequent criticisms of earlier versions of GECs, particularly around double-counting, additionality concerns, and low trading volumes.[80] The scope of projects eligible to claim GECs also expanded significantly: earlier iterations allowed only utility-scale solar and onshore wind, but new GEC rules allow for all types of solar and wind—including distributed generation—as well as geothermal, hydro, and biomass generation.[81] Just as RPS standards will require provinces to reference GECs as evidence of their renewable consumption, inclusion of distributed generation in GEC rules will provide a push to distributed renewable deployment: another marriage of post-Shuangtan policy priorities.

Improving GEC robustness is also important in improving the viability of green power purchase agreements (GPPAs), which have emerged as an area of interest for C+I electricity consumers after energy security fears in 2021/2022. Post-Shuangtan, in order to reduce their emissions footprint, large C+I producers can now pursue a combination of GPPAs, GECs, and/or on-site distributed generation. C+I producers will also benefit from lower provincial grid emissions-intensity metrics as provinces meet RPS targets. All of these factors are intimately linked to post-Shuangtan breakthroughs in the power sector. Even with these developments having pre-Shuangtan antecedents, their post-Shuangtan intensification has been palpable, and they will continue to benefit from the policy momentum created by different components of power sector reform.

2.5 Assessing coal capacity expansions

The previous four subsections detail important strides made towards power sector decarbonization since Shuangtan. It is still important, however, to compare these developments with the massive expansion of new coal plants permitted since 2020. The largest permitting spree began in 2022, in response to the compounding energy security fears of 2021: since early 2022, over 150 GW of coal projects have been permitted (more than current coal capacity in the UK and EU combined).[82] These decisions are undoubtedly a response to the energy security issues of 2021 and 2022, and represent serious threats to China's near-term path to Shuangtan targets, particularly peak CO_2 emissions by 2030 and a phase down in coal consumption from 2026.

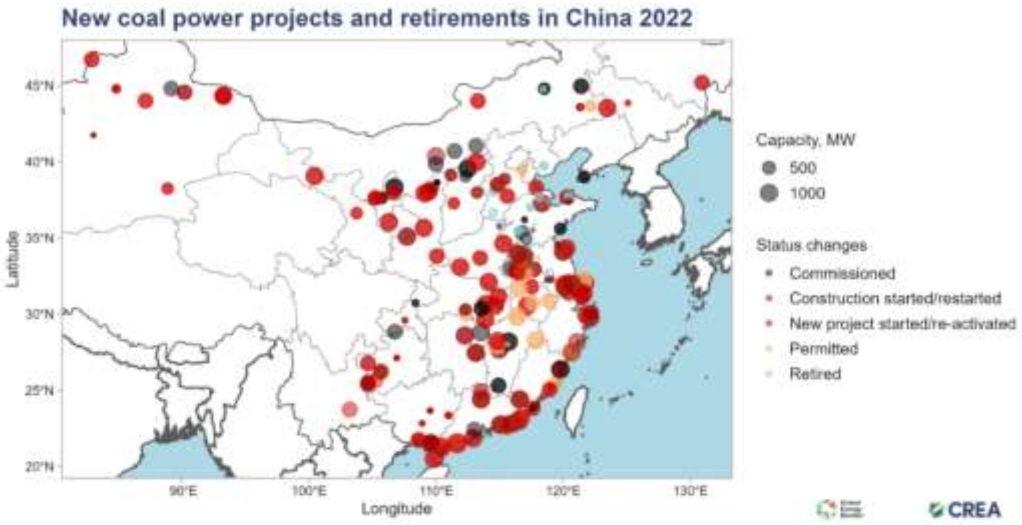
A number of factors, however, indicate a less dire prognosis for this buildout than some have speculated. Firstly, the provinces with the largest coal buildouts are the Eastern demand centres:

---

[77] NDRC. (2021d).
[78] Polaris Carbon Steward (2022).
[79] NDRC (2023b).
[80] Hove and Xie (2023).
[81] Fishman (2023).
[82] Champenois *et al.* (2023).

Guangdong, Jiangsu, and Shandong are three of the four top permitting provinces. As outlined earlier, these provinces are also among the most active in pushing forward ambition on distributed power generation, grid flexibility, and liberalized power markets. In responding aggressively to short-term energy security rhetoric, these provinces are currently pursuing an “all of the above” approach to avoiding future power crunches. But as these provinces improve demand management and grid flexibility policies, fewer of the initially permitted backup coal generators will be necessary. Some analysts have speculated that some of the “rush” to grab permits in the post-2021 period is precisely because coal companies expect stricter permitting guidelines to come into effect when the energy security imperative weakens.[83]

Figure 4: China’s permitted coal plants by province, 2022



Note: This map is for illustrative purposes and does not represent the expression of any opinion concerning the legal status or sovereignty of any country or territory, the delimitation of frontiers or boundaries or the names of any territory, city or region.

Source: CREA[84]

On the part of coal generators themselves, it will also become increasingly difficult to proceed with projects in liberalized power markets without guaranteed power offtake agreements (made impossible by the reforms of Notice 1439). The threat of extremely low utilization rates may discourage final completion of some of the coal plants that received initial permitting in the past two years. In addition, these coastal provinces are among those with the biggest renewable energy manufacturing industries, which is also likely to continue pushing them towards ambitious renewable deployment metrics. These local factors will all likely combine to limit the total climate effect of recent coal permitting. While this may result in coal *capacity* continuing to rise after 2026, it does not guarantee that coal *consumption* (and emissions) will.

Secondly, long-term policy reactions to energy security fears have not called Shuangtan goals into question. NDRC guidance has been to push for liberalized power markets and provincial interconnections, even if short-term increases to coal mining are also deemed necessary. There has been no official deviation from rhetoric around the importance of building a new energy system that has renewables at its core, rather than coal. Rhetoric of coal as the “ballast stone” of the Chinese energy system may gain purchase in moments of energy security anxiety, but government documents still promise that coal will transition to a supporting role. In the long term, looking back at the initial post-

[83] Champenois *et al.* (2023).

[84] Myllyvirta, L., Aiqin Yu, Champenois, F., and Xing Zhang (2023). ‘China permits two new coal power plants per week in 2022’, Centre for Research on Energy and Clean Air, Global Energy Monitor, 27 February, https://energyandcleanair.org/publication/china-permits-two-new-coal-power-plants-per-week-in-2022/

Shuangtan period of 2020–2022 may be remembered as important precisely because Shuangtan ambition *was* deepened across many policy verticals, despite energy security fears. While the expansion in coal permitting is a relevant part of the post-Shuangtan policy reaction picture, it is not its definitive element.

Nonetheless, it is impossible to deny that this flurry of permitting makes the long-term implementation of Shuangtan more complicated. It likely threatens the 2060 goal more than the 2030 goal, but it makes discussions of "accelerated peaking" appear less likely, and suggests that the idea of a "climb to the peak" of 2030 emissions may still be relevant in the minds of some Chinese policymakers and businesses. This predicament likely means that as China plots a path towards reducing coal consumption in the 15th FYP (2026–2030), it will need to come face-to-face with the financial challenges of very low utilization rates for coal generators. This situation could result in rules that place more of the financial burden of keeping coal plants afloat on renewable generators themselves, or other policy mechanisms (like capacity markets) to find new revenue streams for coal generators. All of those would add further economic costs to China's power sector clean transition.

This section presents four important components of power sector policy which have seen important progress since Shuangtan. The pace of post-Shuangtan policy steps is particularly notable in power market liberalization, indicating that power market reform has become a higher priority level for central and provincial officials post-Shuangtan than it was in the 2010s. This may be driven by a combination of Shuangtan, energy security fears, and longstanding policy plans. But Shuangtan's role in promoting a more renewable focus (and "new power system" focus) in this agenda is notable. While implementation challenges—like provincial pushback to some transmission reform—will persist, central planners are now making a more concerted effort to overcome that resistance. Energy security fears complicate these challenges, but are less likely to derail the reforms than they may have been in the past. Even if both the "old" and the "new" have expanded post-Shuangtan, the policy steps outlined here help lay the groundwork for a swifter transition to the "new".

3 Renewable energy manufacturing policy

An equally important element of the political sustainability of Shuangtan has to do with Chinese renewable energy manufacturers and their relationship with government—both local and central. These firms are the producers of the hardware of China's energy transition, as well as a key future growth sector in the Chinese economy. As described in section 1 of this paper, a majority of outside observers focus on the period of the 2000s as the high-water mark for Chinese state support for green industries, especially solar and wind. How (and if) that treatment has changed post-Shuangtan is a key variable for Shuangtan implementation, which has so far received relatively limited outside attention. This section presents the post-Shuangtan policy environment for Chinese renewable energy manufacturers from three angles: the traditional support model from local governments, the pivot of Chinese renewable energy companies to serve both domestic and overseas markets, and a case study of the (now) booming Chinese offshore wind industry. These accounts paint a picture of policy continuity with earlier eras of local government support, combined with new commercial confidence from renewable energy manufacturers as they enjoy the unprecedented promise of both domestic and international demand.

3.1 Local government support

As seen in changes to China's GEC rules and the expiry of FITs, China's approach to subsidies for renewable energy *consumption* has shifted post-Shuangtan. However, just as price parity and RPS now guide renewable deployment rather than subsidy-driven programmes, many of the same principles behind early local government support to renewable energy *manufacturers* hold true today. In fact, despite (or perhaps because of) the breakneck growth of these firms and Chinese dominance in these sectors, they may receive even more local government support today than in the past.

One reason why Chinese renewable manufacturers continue to enjoy local government support is that the most relevant players are now more commercially influential than they have ever been before. In the 2010s, the wind and solar industries in China underwent sharp periods of market consolidation. As a result, a smaller number of players command large market shares today: in solar, for example, China's top producers of LONGi, Trina, Jinko, JA, and Tongwei account for over 80 per cent of domestic solar wafer production and over 60 per cent of domestic module production.[85] Due to this consolidation, most of the remaining renewable energy giants in China today are profitable. This is an important difference from the first boom era of Chinese renewable energy manufacturing, when policy support from local governments pushed so many new players into the market that competition became overly intense and many producers struggled to survive. Now, local governments have more confidence that their “local champion” green manufacturers are sustainable sources of local economic growth, reducing the downside risks to closer local government cooperation.

This consolidation has also meant that there is a smaller number of local governments involved in the most important decisions for these renewable energy manufacturing giants. LONGi in Xi’an is a particularly apt case study in how local policy incentives continue to push large Chinese renewable manufacturers forward since 2020. LONGi is the world’s largest solar producer and has ambitious expansion plans for its manufacturing footprint. In 2020 alone, LONGi announced three major manufacturing investments in Shaanxi province.[86] As part of this, LONGi contributed to the strategic priorities of the local government in Xi’an, in particular the Xi’an Aerospace Industrial Base, with which LONGi signed a 10 GW manufacturing deal in February 2020. For at least one of these projects, LONGi received traditional local policy incentives like direct investment, land concessions, and electricity connections. In January 2023, LONGi announced that it agreed to build a 100 GW solar wafer facility and 50 GW solar cell facility in the Xixian New District of Xi’an.[87] The project will attract almost RMB 50 billion in investment and create 15,000 jobs in the Xixian New District, one of the national new districts approved by the State Council in 2014 to drive industrial growth and urban development (and a key policy priority for the Xi’an government).

Beyond the clear economic benefit brought by LONGi’s operations in Xi’an, the local government continues to push LONGi forward because new energy is one of its stated focus sectors for industrial prioritization.[88] And LONGi itself is now exploring other subsets of new energy beyond its traditional core competency in solar: in August 2023, LONGi successfully delivered China’s largest pilot green hydrogen project, using a combination of LONGi solar and electrolyzers.[89] As a result, Xi’an officials can claim that LONGi is contributing to green industrial priorities outside of just solar. Beyond Xi’an and LONGi, new energy manufacturing counts as “high quality development” for the industrial development metrics of local governments. This metric has become significantly more important in recent years as central government guidance prioritizes new development models. This means that, at the same time that highly polluting projects may attract scrutiny from the central government, local planners can be confident of receiving plaudits for green industrial buildouts. This arguably creates more attractive positions for green manufacturers vis-a-vis local governments today than at any other time before—particularly well established green manufacturers.

One example of a local government pursuing development along these lines since 2020 is Inner Mongolia. With a sparse population, ample energy access (albeit coal-dominated), and closer proximity to the upstream elements of green supply chains, Inner Mongolia has made green industrial development a core growth strategy since Shuangtan. In its 2022 provincial FYP for energy, Inner Mongolia begins by stating that it will follow Xi’s guidance on development and “unswervingly follow the new path of high-quality development oriented by ecological priority and green development”.[90] In doing so, it expresses plans for building new energy industrial clusters for wind, solar, hydrogen, and energy storage. Since Shuangtan, Inner Mongolia’s ability to capture new green industrial investments has been remarkable. JA Solar has announced plans for a 20 GW ingot/wafer and 30 GW solar cell facilities.[91] Canadian Solar this July announced plans of a similar magnitude.[92] Shanghai-based new

[85] CEEC (2023).
[86] Qingru Ma *et al.* (2020).
[87] Polaris Solar Photovoltaic (2023).
[88] Sohu.com (2022).
[89] Weixin (2023).
[90] Inner Mongolia New Energy Network (2022).
[91] Bhambhani (2023).
[92] Gardham (2023).

energy developer Envision announced plans for a "Net-Zero" industrial park in Inner Mongolia's capital Ordos, where several other Chinese green manufacturers (including LONGi) will participate.[93] All of this work for Inner Mongolia paid off in June 2023, when Xi visited Inner Mongolia and applauded its new energy development efforts, stating that green development is "the path that must be taken" for Inner Mongolia.[94] Provinces can aspire to fewer more direct development blessings than that. Inner Mongolia's policy offerings to entice green manufacturing investments on this scale likely include preferential treatment on land access, energy input prices, and other local benefits.

Eastern Coastal provinces—many with the longest legacies of early policy support for renewable manufacturing—likewise remain active in this space. For example, Jiangsu, Guangdong, and Shandong remain the top three provinces in terms of number of solar PV companies today (which may also explain these provinces' enthusiasm for expanding distributed solar installations).[95] The continued relevance of Jiangsu in solar production is testament to the long-term effects of early efforts to develop solar supply chains, with major producers like Trina Solar and Canadian Solar still operating in Jiangsu. In Jiangsu, despite Trina Solar catching the ire of US trade restrictions, local government support continues with new programmes to attract top scientific talent to Changzhou for Trina and other manufacturers.[96] As outlined in the next subsection, these provinces are also active participants in the unfolding competition between local governments over developing offshore wind manufacturing champions.

Figure 5: China's solar PV firms per province, 2022

Note: This map is for illustrative purposes and does not represent the expression of any opinion concerning the legal status or sovereignty of any country or territory, the delimitation of frontiers or boundaries or the names of any territory, city or region.

Source: Hefang Mu (2023)

[93] Zheng Xin and Yuan Hui (2022).
[94] State Council Information Office (2023).
[95] Hefang Mu (2023).
[96] Crowther (2023).

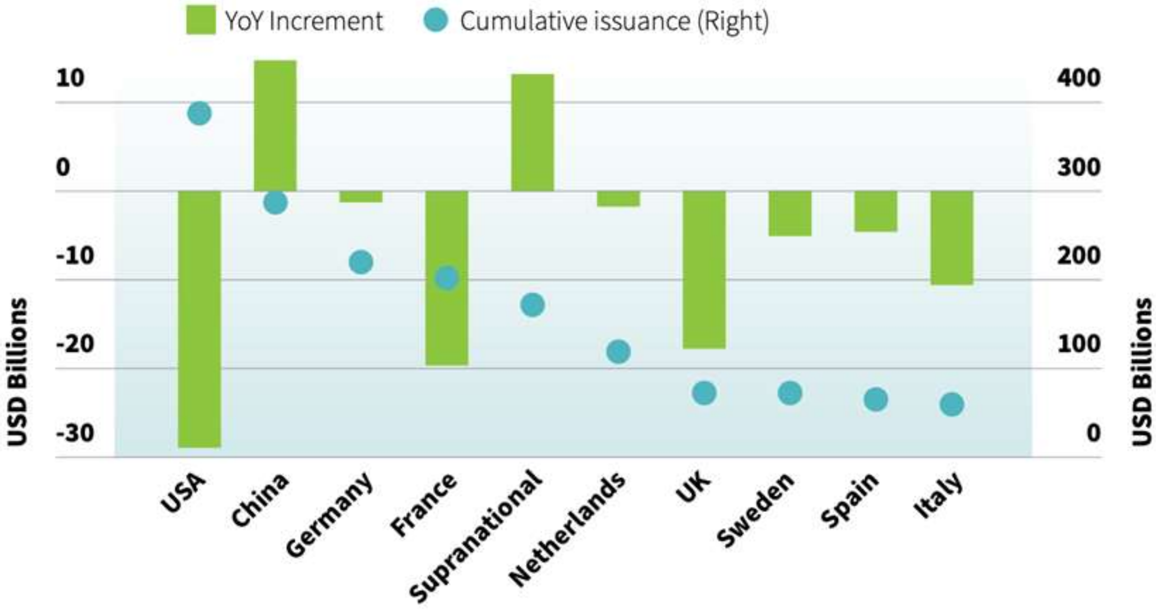
Further, the binding targets of the RPS are providing additional urgency for provinces that were not early adopters of renewable energy industrial plans. With the inevitability of rising RPS metrics, many provinces are seeking ways to ensure that more of its associated economic activity remains within their province. Recently, multiple provinces have started setting local investment stipulations for companies that want to participate in new energy contracts: since 2021, these have included Yunnan, Guangxi, Anhui, Guizhou, Ningxia, and Hubei.[97] A similar phenomenon can be seen in the whole-county solar programme, where local governments have made access to rooftop development opportunities contingent on local manufacturing investments.[98]

In addition, more parts of the renewable energy value chain are moving towards Western and Northern provinces (like Inner Mongolia). While not among the early drivers of renewable energy manufacturing, these provinces are closer to raw material extraction and have a higher overall development imperative than prosperous coastal provinces. This shift is likewise spreading the spatial distribution of renewable energy manufacturers across most corners of China in ways that it was not 10 years ago. Beyond Inner Mongolia, other Northern and Western provinces like Ningxia, Qinghai, and Gansu are all active on renewable industrial development. Trina Solar announced a major industrial park investment in Qinghai last year, adding to the Qinghai presence of Canadian Solar and other solar manufacturers.[99] Gansu planners in 2022 set a goal to build a RMB 100 billion "new energy industrial chain" in the province, with more than 100 new energy suppliers reportedly entering Gansu since 2021.[100] These movements will make the political economy of green development more sustainable across different geographic regions in China, including in the Western and Northern provinces most targeted for developmental prioritization writ large.

Financial policy support has likewise been a key enabler of post-Shuangtan expansions, with local governments active in pursuing new mechanisms for attracting green financial support. In 2022, more than 15 provinces published new rules to expand uptake for green financial products.[101] Provinces driving green financial growth in China are the major corporate coastal centres of Beijing, Shanghai, and Guangdong, but Western and Northern provinces are also increasingly involved. At least 20 "local green special bonds" have been issued in China as of June 2023, identified by some commentators as a way for local governments to both attract new industries and to address local debt anxieties.[102] In 2022, China was the largest issuer of green bonds in the world, growing over 20 per cent in a year when most other major markets saw contraction in green bond issuance.[103] Central guidance post-Shuangtan has been essential in the ability of financial institutions (and corporates) to raise green debt, especially consolidation of green bond issuance standards by central authorities in 2021 and 2022.[104] Notably, some of these post-Shuangtan changes are aimed at aligning Chinese standards with international green finance standards. This would attract more foreign capital for Shuangtan-related projects in China, adding another reason for central planners to look fondly on green development.

[97] Polaris Solar Photovoltaic (2022).
[98] Capital Research Association (2023).
[99] Trina Solar (2022).
[100] Zhandong Wang (2023).
[101] China Lianhe Credit Rating Company (2023).
[102] Gong Fang and Yuan Yuze (2023).
[103] Climate Bonds Initiative (2023).
[104] Lu Min (2023).

Figure 6: Green bond issuance from China expanded in 2022



Source: Climate Bonds Initiative

The result of this combination of local government and commercial enthusiasm could even turn into overcapacity for renewable energy manufacturers in the medium term. In May 2023, the President of LONGi Solar stated that, if the enthusiasm among Chinese solar producers to expand manufacturing continued until the end of 2024, the industry's total production capacity could reach as much as 1,000 GW.[105] That quantity would be more than double global solar demand in 2022 and would be capable of supplying almost all of China's goal of 1,200 GW of combined solar and wind installations by 2030. While this specific prognosis may be hyperbolic, this sentiment is a reaction to the massive mobilization of local governments and private/public enterprises towards green industrial development since Shuangtan. Even for incumbents as well equipped as LONGi, the scope of this rush could create longer-term challenges. But for China's green industrial footprint more broadly, it is a positive indicator of long-term political staying power.

3.2 Case study: Offshore wind

China's offshore wind industry provides an indicative case study of how renewable energy manufacturing policy remains fiercely active post-Shuangtan. China is a relative latecomer to the offshore wind industry, lagging behind European companies which started developing offshore wind projects decades earlier. Offshore wind was also not a primary focus for the first round of Chinese industrial policies in the 2000s. In 2015, for example, China installed only 100 offshore turbines, with a total capacity of just 360 MW—far from its position of global leadership in solar manufacturing and deployment by 2015.[106] In recent years, however, Chinese offshore wind manufacturers have rapidly risen to a position of global prominence, particularly post-Shuangtan. In 2021, China installed almost 20 GW of offshore wind (more than 50 times its total from 2015), and turbine designs by Chinese firms are now larger than the biggest offerings from Western competitors.[107] In 2022, almost 75 per cent of all global offshore wind turbines were produced by Chinese manufacturers.[108]

---

[105] China Business News (2023).
[106] GWEC (2016).
[107] Barla (2023).
[108] Waite (2022).

This rapid rise in Chinese offshore wind manufacturing can be directly linked to local government policy support, particularly from Eastern and Southern coastal provinces. Of these, Guangdong is perhaps the most significant. The offshore wind industry first emerged as an important national industrial priority in the 13th FYP, covering the period of 2016–2020. Guangdong released its own roadmap for offshore wind development as early as 2017, with planning initially spanning all the way until 2030.[109] More recently, the offshore wind industry features prominently in Guangdong's 14th FYP for high-value industrial clusters, especially notable given Guangdong's reputation as a leading industrial province in China.[110] Since Shuangtan, Guangdong has been active in providing policy incentives to attract new entrants to its local offshore wind value chain. These have included a RMB 200 million fund to promote offshore wind industrial clusters, and an annual RMB 300 million in research and development funding for marine industries including offshore wind.[111] In 2020, the Guangdong government approved an industrial development fund specifically for the Yangjiang offshore wind industrial cluster, with Guangdong officials further expanding Yangjiang's intended scope in 2021.[112]

While this policy environment has propelled Guangdong to a leadership position in offshore wind industrial expansion, it is not alone. In total there are now over 20 different offshore wind industrial clusters in China, thanks in large part to policy impetus provided by the 14th FYP.[113] The three largest of these clusters, which all aim to generate annual economic value of over RMB 100 billion, are Dongying Offshore Wind Industrial Park in Shandong, Yanjiang Offshore Wind Equipment Manufacturing Industrial Base in Guangdong, and Fangchenggang Offshore Wind Manufacturing Park in Guangxi. These clusters are almost all based in Eastern/Southern coastal provinces, where proximity to offshore wind projects is the most convenient, and where industrial cluster learning capabilities are already very high. The similar industrial visions of so many provinces is testament to the fact that industrial policy still underpins the frontier of renewable energy manufacturing in China. This post-Shuangtan push is also important because it will enable Eastern provinces to add more local renewable production than previously expected, reducing both the need to build more coal-fired backup plants, and the need to import renewable power from other provinces. And offshore wind firms will contribute to the rising economic and political importance of renewable manufacturing in these provinces, providing another local incentive for the long-term implementation of Shuangtan in these provinces.

[109] Guangdong DRC (2018).
[110] Guangdong DRC (2021).
[111] Guangdong Energy Bureau (2022).
[112] People's Daily (2023).
[113] Song Gu *et al.* (2022).

Figure 7: China's wind industrial clusters by province, 2022

Note: This map is for illustrative purposes and does not represent the expression of any opinion concerning the legal status or sovereignty of any country or territory, the delimitation of frontiers or boundaries or the names of any territory, city or region.

Source: Crowther, OIES[114]

Just like their predecessors in the solar PV space, this expansion now has Chinese offshore wind producers looking to foreign markets to seize on international offshore wind demand. Mingyang, one of the largest Chinese offshore wind producers, raised capital in July 2022 to expand its manufacturing footprint in Europe.[115] The fact that Mingyang views itself as capable of competing in the domestic market of many of the world's oldest offshore wind producers is indicative of the confidence levels in the Chinese offshore wind industry today. It also underscores how the trajectory that offshore wind manufacturers are experiencing today is not unlike what solar PV manufacturers experienced 10 or 15 years ago. Local governments undergo a period of intense policy support competition, potentially preceding a period of cut-throat market consolidation. The industrial policy playbook from local governments remains the same, and has perhaps grown even stronger post-Shuangtan with the more vocal pairing of green manufacturing and high-quality development. Regardless of international trade implications, this is likely a positive force for China's path towards Shuangtan targets.

3.3 International manufacturing expansions

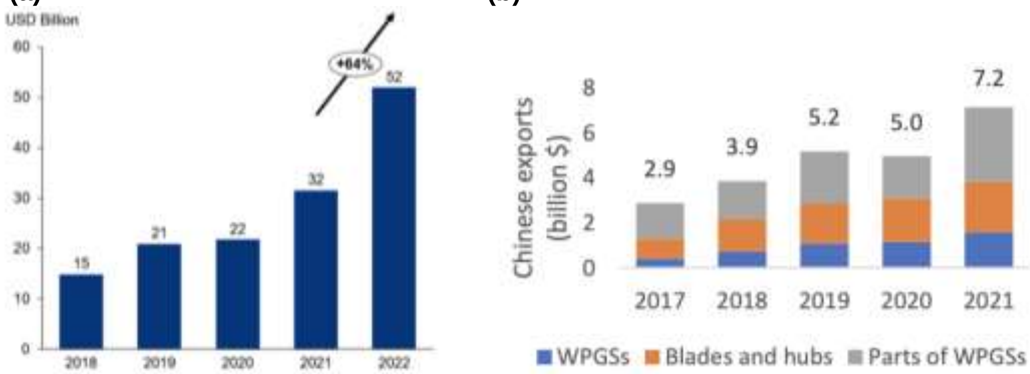
Chinese renewable energy manufacturers today are confronted with the best of both worlds in terms of the 2000s and 2010s. In the 2000s, despite weak domestic demand, Chinese renewable energy manufacturers targeted export markets where renewables received aggressive subsidies. As those subsidies rolled back in the late 2000s and early 2010s, Chinese manufacturers were forced to prioritize the domestic market, where effective policy pushes drove rapid renewable growth. These two periods were in sharp contrast to each other: in the 2000s, international demand existed largely without domestic demand, while in the 2010s domestic demand skyrocketed largely without international demand.

[114] Adapted from Song Gu et. al. (2022)
[115] Griggs (2022).

Today, however, the domestic and international markets are *both* running at full tilt. This best-of-both-worlds situation means that Chinese renewable energy manufacturers are growing increasingly confident in their future market outlook. This sentiment is driving enthusiasm for new manufacturing capacity in both domestic and foreign markets, and increasing the economic footprint of Chinese renewable manufacturers. China's continued growth in renewable energy manufacturing post-Shuangtan has been palpable. *Bloomberg New Energy Finance* estimated that China accounted for over 90 per cent of global investments in clean energy manufacturing in 2022, with a total of over USD 70 billion.[116] This figure is higher than the share of clean energy manufacturing investments China attracted in the pre-Shuangtan years of 2018, 2019, and 2020. The two subsets of clean energy manufacturing which attracted the most global activity in 2022 were batteries (USD 45 billion) and solar (USD 23 billion)—areas where China's presence in supply chains is already especially strong and only intensifying post-Shuangtan. Beyond domestic demand, 2022 was also a bumper year for Chinese renewable exports. Solar module exports almost doubled, from 89 GW in 2021 to 155 GW in 2022.[117] China's presence in wind exports is smaller but likewise growing quickly: 2021 exports of 1.6 GW grew more than 60 per cent from 2020.[118] This is a material change for China's wind industry, which has historically been more domestically focused than China's solar industry. China's export presence in batteries and electric vehicle supply chains is similarly intractable.

Figure 8: (a) China's photovoltaics exports (2018-2022); (b) China's wind turbine exports

(a) **(b)**



Source: (a) Wood Mackenzie, 2023; (b) IHS Markit, Global Trade Atlas

Chinese renewable companies are also increasingly pursuing manufacturing investments in foreign countries. Since the passage of the US's Inflation Reduction Act (IRA) in 2022, multiple Chinese renewable energy companies have announced US manufacturing plants. Chinese battery giant CATL will build a manufacturing plant in Michigan, LONGi will build a solar manufacturing plant in Ohio, and JA Solar will build a manufacturing plant in Arizona.[119] These investments are all designed to take advantage of US policy incentives that mirror some aspects of China's early renewable industrial development. CATL and other Chinese battery manufacturers are active in Europe, where Chinese, Japanese, and Korean battery manufacturers represent almost half of planned battery manufacturing capacity until 2030.[120] As the EU pursues its Net-Zero Industry Act (which is largely based on IRA structures), Chinese solar and wind companies will likely pursue more direct manufacturing investments in the EU as well. While the jury is still out on the success of these ventures, they represent an entirely new strategic position for Chinese renewable firms to occupy.[121] As they invest in other countries, they will export some of China's vision of "high-quality development" overseas, helping improve China's fossil-heavy legacy of foreign energy investments in the past.

---

[116] Bloomberg (2023a).
[117] Chen (2023).
[118] Bloomberg (2022).
[119] Rapoza (2023).
[120] Waldersee (2023).
[121] Crowther (2023).

Particularly in a time when industrial trade tensions with the US and EU are high, the diplomatic successes that these foreign investments may bring could raise the profile of renewable energy manufacturers in the eyes of the central and local government. Although governments like the US and EU are still conflicted on how (or if) to welcome Chinese firms in their domestic green industrial programmes, this trend is already under way. And Chinese manufacturers are taking steps to reduce some of the obvious potential friction points in the relationship (like Trina Solar stating it will use only US and European polysilicon in its new Texas manufacturing facility).[122] These expansions are high-risk, in terms of both political risk *and* economic risk, indicating just how much confidence these producers are feeling in a post-Shuangtan (and perhaps post-Covid) environment. While these changes may be driven as much by external changes to foreign renewable energy demand as by Shuangtan itself, they still warrant inclusion as a positive source of long-term momentum towards Shuangtan since 2020.

The cumulative picture that emerges from this post-Shuangtan landscape for renewable energy manufacturers combines longstanding policy instincts with new commercial opportunities *and* political blessing. In cities and provinces that have already had local green manufacturing champions, the market outlook (both domestic and international) has pushed local governments to support ambitious expansions by manufacturers. This has coincided with important changes in the geographic distribution of renewables manufacturers in China, with Western and Northern provinces pursuing even more active programmes to attract renewable energy manufacturing investments as part of their high-quality development plans. And green manufacturers (even those with headquarters in other provinces) have been eager to engage in these expansions. This expansion may even mean that renewable manufacturing *overcapacity* is a more plausible medium-term risk than undercapacity. These trends will all contribute more reasons for the central government to continue support for policies that support domestic renewable energy consumption, and for efforts to export renewable energy technologies. That, in turn, may make green industries a more plausible driver of China’s future industrial model than would have appeared likely pre-Shuangtan.

4 Conclusions

4.1 Shuangtan signal: Critical juncture?

This insight has sought to evaluate post-Shuangtan policy actions in two key areas of Chinese energy and climate policy: power sector policy, and renewable energy manufacturing policy. While these policy areas do not cover the entirety of post-Shuangtan energy/climate policy changes, they are key drivers of Shuangtan implementation. On both fronts, Chinese policymakers have made significant breakthroughs since Shuangtan. In the power sector, the whole-county solar programme is an entirely post-Shuangtan effort, giving provincial and county-level governments the chance to seize on the political opportunity of green policy enthusiasm. Liberalized power markets, RPS, and GECs, on the other hand, can all trace their lineage to pre-Shuangtan announcements. But in all three cases, serious action to push these concepts into policy maturity only materialized post-Shuangtan: NDRC guidance in 2021 and 2022 for power market liberalization, post-2021 binding indicators for RPS obligations, and 2023 policy revamps for GECs. Power market liberalization is especially apt as a sector where the role of Shuangtan appears to have been decisive: despite the first announcements of power market reform dating all the way back to 2014, little substantial progress was made between then and 2020. Only since Shuangtan has there been more top-down political focus on power market reform to overcome provincial scepticism. For centrally set rules like RPS and GEC, they benefit from a virtuous cycle in post-Shuangtan Chinese energy policy, where RPS requirements help push GEC uptake, and vice-versa. Distributed generation and liberalized power markets share a similar dynamic.

These developments all combine top-down guidance with provincial/local-level implementation. RPS and GEC progress are more top-down, while power market reform and distributed renewable generation

---

[122] Pickerel (2023).

are more reliant on local government buy-in. The fact that both types of policy are proceeding is evidence that Shuangtan-related policy priorities have purchase on many levels of the Chinese government system. And even where these policy steps may not be causally linked to Shuangtan, policymakers see Shuangtan as an advantageous justification for policy steps: this can be seen in references to carbon peaking and neutrality in the texts of most of the post-Shuangtan policy documents referenced here. The persistence of Shuangtan priorities despite other short-term anxieties (particularly energy security) is also an important data point in making an early estimate of Shuangtan's long-term staying power.

In renewable energy manufacturing policy, post-Shuangtan lessons reflect a continued enthusiasm by local governments to pursue industrial policy incentives for in-favour industries. In the time since 2020, renewable energy manufacturing and "green development" have risen to an almost unassailable position in that hierarchy. Rather than necessarily pushing local governments into new types of policy support for these manufacturers, though, the post-Shuangtan environment is pushing them to be *more ambitious* with their pre-existing playbook of industrial policy support. With breakneck demand growth in both the domestic and international market, Chinese green manufacturers are ready to indulge this local government enthusiasm, pursuing manufacturing capacity expansions across many green subsectors. With concepts like "high-quality development" and carbon peaking and neutrality now a mainstay in central government rhetoric, local governments are unlikely to change course on this direction so long as bullish sentiment in the commercial sector persists.

These takeaways raise again one of the questions posed in the Introduction of this paper: does Shuangtan represent a critical juncture in Chinese energy and climate policy? While the initial posers of this question in late 2020 suggested that it was too early to answer, the evidence three years on presents a more compelling picture of Shuangtan as a potential critical juncture—at least in specific areas.

In the power sector, Shuangtan likely *was* a critical juncture: the policy reforms that have made major strides since 2020 have benefited, directly and indirectly, from the political signal sent by Shuangtan. Even if some (or many) of them may have been headed in this direction pre-Shuangtan, Shuangtan's presence has helped cement those reforms, despite short-term energy security concerns. In other words, Shuangtan played a key role in pushing reforms forward in a period when policy backsliding was a serious risk. Further, the pre-Shuangtan policy paralysis in which some elements of power sector reform were stuck reflects a key component of critical juncture theory: that there should be pre-juncture conflict over the specific issue area. Between electricity prices, interprovincial transmission rules, and guaranteed offtake hours for coal plants, there was a high degree of conflict in pre-Shuangtan power sector interests. That made the break offered by Shuangtan a more important development, and a more plausible critical juncture as Chinese planners move towards a new energy system.

In terms of renewable energy manufacturing, Shuangtan likely did *not* present a critical juncture. Rather than departing from previous policy patterns, it reinforced the rationale for why local governments have been supporting renewable energy manufacturers in China for over 20 years. Indeed, there was likely not significant pre-juncture policy conflict over local government support for renewable manufacturers. Most local governments would be broadly supportive of such measures in principle. What *is* a relevant change is that post-Shuangtan, more local governments have made efforts to capitalize on green industries as future growth drivers, with green supply chains increasingly moving from coastal provinces to Western and Northern provinces. The scale to which these provinces have embraced green manufacturing in recent years is challenging to imagine without the political signal of Shuangtan.

4.2 Lessons from energy security anxieties and coal risks

While the above conclusions are largely positive from a decarbonization point of view, post-2020 fears around energy security and coal capacity are important parts of the post-Shuangtan policy picture. The most basic question raised by these post-2020 fears is: will energy security anxieties force Chinese planners to double down on a centralized, administratively determined, coal-heavy power sector? And will that decision push planners to delay existing (or future) plans for decarbonization of the power sector?

On both points, despite the extent of negative news related to coal capacity, direct policy signals in China post-Shuangtan have *not* indicated a departure from the policy reforms necessary to move to a more decarbonized and market-driven power sector. The evidence for this claim forms the bulk of section 2 of this paper, with major steps made on power sector issues like spot market construction, interprovincial transmission reform, and RPS/GEC regulations. Beyond these policy steps, the post-2021/2022 behaviour of energy consumers like C+I players will help make possible new approaches to meeting peak demand moments. These outages form the crux of Chinese policymaker concerns about energy security. As more power consumers build their own distributed renewable generation and storage, and as power price ranges widen to allow for demand responses, grid planners will likely gain more confidence in meeting peak loads *without* the full extent of recently permitted coal buildouts. They will feel more confidence to do so as Chinese planners decide exactly what a modern energy system looks like, a process which will continue to be refined in the 15th FYP and beyond. There have been no indications that the high-level guidance of a need for a redesigned energy system has been abandoned due to energy security concerns. If anything, the power sector reforms outlined here have given grid planners more ability to argue that a flexible and decarbonized power grid should be the core of that new system. This is possible even in some of the provinces that have approved the largest coal buildouts, like Guangdong, Jiangsu, and Shandong. The deepening of policy support from local governments to renewable energy manufacturers will lend further strength to this argument.

Regardless, the spectre of over 150 GW of new coal capacity coming online is a serious risk. Even if those coal plants are forced into extremely low operating rates to serve a nominally “supportive” role to a renewables-based system, they will weigh on many aspects of the power system. They may require new financial arrangements like capacity markets which raise costs for consumers, even as significant investment remains to be made in the Chinese power sector. Or more rules could force renewable generators to lend financial support to coal generators, reducing the economic appeal of some renewable projects. And the construction of such a large fleet of new plants could give new life to the political influence of coal miners and coal generators. These factors create a real risk that China will face an unprecedented policy challenge regarding coal as it seeks to peak coal consumption in the 15th FYP, and an even more extreme challenge after 2030. How that challenge will play out is difficult to speculate on; but the staying power of Shuangtan policy goals should at least provide momentum for policy solutions that minimize the negative effects of such a large coal buildout.

4.3 Long-term implications: Hardware and software, Shuangtan trajectories, and external environments

This analysis supports the main takeaways of the hardware/software framework, proposed by Meidan, Hove, and Andrews-Speed in 2021, in multiple ways. It confirms that building the hardware of the energy transition (renewable energy capacity buildouts) is unlikely to be a major inhibitor of China’s energy transition. This paper has catalogued how, through both power sector policy and manufacturing policy, China is likely to double down on the hardware benefits of the energy transition, and is likely to surpass its own high-level goals related to it.

In terms of software policy support, from power market liberalization to RPS, there is also reason for cautious optimism. While the post-Shuangtan changes on these topics are important steps forward, they continue to underscore just how difficult it is in China to make sweeping changes to policy areas as entrenched as grid design. Even when significant steps forward are made, the future range of outcomes for power sector policy reform is much wider than those for renewable energy manufacturing. But the evidence presented here suggests more central efforts at addressing those challenges than would have happened without Shuangtan.

On balance, post-Shuangtan policy changes have likely been more consequential in the power sector than in renewable energy manufacturing, but they are closely linked. Policies like whole-county solar and the RPS are informing both private market confidence in manufacturing expansions, and the entry of central state-owned enterprises into the renewable manufacturing business. The persistence of high-level signals on power sector reform also shows that the central government is becoming more active on trying to push provinces into actions which the provinces have, until recently, resisted. While these developments still have a long way to go, they reflect the central government placing a higher public emphasis on power sector policy post-Shuangtan. More central government focus on power sector reform and high-quality development is also pushing provinces that have not traditionally prioritized green development to become some of the most active patrons of green industries. Indeed the geographic spread of green industries to Western and Northern provinces is one of the material developments since Shuangtan. This spread will greatly expand China's renewable manufacturing capacity, but may contribute to long-term complications as renewable manufacturing competition intensifies and more external attention comes to the supply chain profiles of these provinces.

In sum, the picture of post-Shuangtan policy action presented here, in the power sector and the renewable energy manufacturing sector, suggests that Shuangtan goals will command significant staying power in the Chinese policy system. While this insight does not perform a quantitative analysis of China's emissions pathways, it does illustrate that at least two important building blocks of Shuangtan implementation have made notable progress in the past three years. These are essential components of China's achievement of Shuangtan targets. This insight also underscores how different policy actions that fall under the policy umbrella of Shuangtan help reinforce one another, likewise bolstering Shuangtan's staying power.

As many analysts have noted, reaching peak CO_2 emissions before 2030 will be an easier task for China than full carbon neutrality by 2060. Factors like the record expansion of distributed solar capacity growth, and commercial confidence of Chinese renewables manufacturers, have led many analysts to predict that China will surpass its 2030 goal of 1,200 GW of wind and solar capacity as much as five years ahead of schedule.[123] And while fears of a "climb to the peak" due to coal capacity expansions are justifiable, the fact of 2030 peaking has not been challenged anywhere. Equally true, however, is that there have *not* been any indicators of an accelerated timeline for either half of the Shuangtan goals. In the medium term, this could emerge as a sore point in international rhetoric around China's climate goals.

Finally, major questions remain about how a more volatile external environment may impact Chinese thinking on Shuangtan and energy/climate issues writ large. As energy/climate issues occupy a higher profile on the international stage, more attention may come to China's domestic policy environment, and to the commercial positioning of its largest renewable energy manufacturers. How a higher risk of confrontational rhetoric on these topics may impact Chinese policymakers' decisions is an important area for further research. Up until now, Chinese leaders have insisted that China will follow its own, China-specific path towards carbon neutrality. In some ways this gives Shuangtan even more political protection domestically, even if it makes accelerated timelines less likely. The most recent version of this sentiment came from Xi just as John Kerry visited Beijing in July 2023, with Xi stating that China's path towards decarbonization will "never be influenced by others".[124] Some of the data points presented here offer cautious optimism that China will make fast enough strides to avoid an excess of confrontational rhetoric—or even provide some policy examples that other countries (particularly developing countries) can learn from. But as the global drumbeat of "increased ambition" intensifies, the net-zero goals of the world's largest emitter will never be far from the centre of attention. Future progress on the policy verticals outlined here will be central drivers of if (or how) that attention materializes.

[123] Global Energy Monitor (2023).
[124] Gan (2023).

Bibliography

Andrews-Speed, P., Zhang, S. and Chao Wang (2020). *Does 2020 Mark a Critical Juncture in China's Low-Carbon Energy Transition?*, Oxford Institute for Energy Studies, Energy Insight 76, https://www.oxfordenergy.org/wpcms/wp-content/uploads/2020/10/Insight-76-Does-2020-mark-a-critical-juncture-in-Chinas-low-carbon-energy-transition.pdf

Anon. (2022). '"It's getting extremely hard": Climate crisis forces China to ration electricity', *The Guardian*, 30 August, https://www.theguardian.com/world/2022/aug/30/its-getting-extremely-hard-climate-crisis-forces-china-to-ration-electricity

Ball, J., Reicher, D., Sun, X., and Pollock, C. (2017). *The New Solar System: China's Evolving Solar Industry and its Implications for Competitive Solar Power in the United States and the World*, Office of Scientific and Technical Information (OSTI), US Department of Energy, https://doi.org/10.2172/1352021

Barla, S. (2023). 'Chinese offshore wind technology is accelerating – I expect 25mw turbines soon', *Recharge News*, 2 February, https://www.rechargenews.com/wind/-chinese-offshore-wind-technology-is-accelerating-i-expect-25mw-turbines-soon-/2-1-1397243

Bhambhani, A. (2023). 'JA Solar to build new solar PV manufacturing cluster with polysilicon, ingot, wafer & module capacity in China's Inner Mongolia', *Taiyang News*, 23 January, https://taiyangnews.info/business/ja-solar-announces-rmb-40-billion-investment-for-new-fab/

Bloomberg (2021). 'China's push for rooftop solar and rural wind boosts producers', *Bloomberg News*, 16 September, https://www.bloomberg.com/news/articles/2021-09-16/china-s-push-for-rooftop-solar-and-rural-wind-boosts-producers

Bloomberg (2022). 'China's wind turbines get ever cheaper as price war hits profits', *Bloomberg News*, 30 November, https://www.bloomberg.com/news/articles/2022-11-30/china-s-wind-turbines-get-ever-cheaper-as-price-war-hits-profits

Bloomberg (2023a). 'Global low-carbon energy technology investment surges past $1 trillion for the first time', *Bloomberg New Energy Finance*, 26 January, https://about.bnef.com/blog/global-low-carbon-energy-technology-investment-surges-past-1-trillion-for-the-first-time/

Bloomberg (2023b). 'China takes its climate fight to the rooftops', *Bloomberg News*, 27 March, https://www.bloomberg.com/news/features/2023-03-27/why-china-rooftop-solar-power-leads-world-on-clean-energy-capacity

Bloomberg (2023c). 'China coal giant "seizing" window of opportunity for new plants', *Bloomberg News*, 3 September, https://www.bloomberg.com/news/articles/2023-09-04/china-coal-giant-seizing-window-of-opportunity-for-new-plants

Capital Research Association (2023). 'A huge project involving 676 counties: County-wide photovoltaic', Capital Research Association Research Group, 10 July, https://mp.weixin.qq.com/s/dTf-wtoIhyvz0eE9m7fA2A

Carbon Brief (2022). 'China Briefing, 24 March 2022', *Carbon Brief*, 24 March, https://www.carbonbrief.org/china-briefing-24-march-2022-14fyp-energy-plan-more-plans-on-energy-storage-and-hydrogen-chinas-emissions-analysis/

CC China. (2021). 'Zhenhua explains in detail the formulation of the 1+N policy system as the timetable and roadmap for achieving the dual carbon goals', *China Climate Change Info-Net*, 27 July, https://www.ccchina.org.cn/Detail.aspx?newsId=73872&TId=57

CEEC (2023). 'In 2023, global photovoltaic installed capacity may exceed 400GW, and industry competition may continue for a long time to the new normal of "one super and many strong"', *LONGi Solar*, 6 March, https://www.ceec.net.cn/art/2023/3/6/art_11026_2526603.html

Champenois, F., Myllyvirta, L., Qi Qin, and Xing Zhang (2023). 'China's new coal power spree continues as more provinces jump on the bandwagon', Centre for Research on Energy and Clean Air, Global Energy Monitor, 29 August, https://energyandcleanair.org/publication/chinas-new-coal-power-spree-continues-as-more-provinces-jump-on-the-bandwagon/

Chen Gang (2015). 'China's solar PV manufacturing and subsidies from the perspective of state capitalism', *Copenhagen Journal of Asian Studies*, 33(1), 90–106, https://doi.org/10.22439/cjas.v33i1.4813

Chen, R. (2023). 'China's module exports hit high in 2022', InfoLink Consulting, 3 February, https://www.infolink-group.com/energy-article/solar-topic-Chinas-module-exports-hit-high-in-2022

China Business News (2023). 'Photovoltaic production capacity is overcapacity and module prices have dropped by nearly 80%. Why do companies still want to expand production?', *China Business News*, 30 June, https://www.stcn.com/article/detail/905678.html

China Energy Network (2022). 'Why did the "county-wide promotion" of photovoltaics fall into "embarrassment from all sides"?', *China Energy Network*, 12 April, https://mp.weixin.qq.com/s/5aeB7XsRgLEMYJpSCPeJlQ

China Government Network (2021). 'Li Keqiang presided over the Executive Meeting of the State Council to make further arrangements for the supply of electricity and coal this winter and next spring to ensure the basic life of the people and the stable operation of the economy', *China Government Network*, 8 October, http://www.gov.cn/premier/2021-10/08/content_5641406.htm

China Lianhe Credit Rating Company (2023). *2022 Green Bond Operation Report*, China Lianhe Credit Rating Company, https://www.lhratings.com/file/f44efb9f330.pdf

Climate Bonds Initiative (2023). *China Sustainable Debt: State of the Market Report 2022*, Climate Bonds Initiative, https://www.climatebonds.net/files/reports/cbi_china_sotm_22_en.pdf

Corwin, S. and Johnson, T.L. (2019). 'The role of local governments in the development of China's solar photovoltaic industry', *Energy Policy*, 130, 283–293, https://doi.org/10.1016/j.enpol.2019.04.009

Crowther, H. (2023). 'Market dilemmas and strategic balancing acts: Chinese renewable manufacturers in an era of geopolitical competition', *Oxford Energy Forum*, 137, 20–23, https://www.oxfordenergy.org/wpcms/wp-content/uploads/2023/08/OEF-137.pdf

David, Andrew (2022). 'Chinese Wind Turbine Export Growth Continued in 2021', US International Trade Commission, March, https://www.usitc.gov/publications/332/executive_briefings/ebot_chinese_wind_turbine_export_growth_continued_in_2021.pdf

De Boer, D. and Fan, D. (2022). 'Impressive progress in China's 1+N policy framework', China Council for International Cooperation on Environment and Development, 11 March, https://cciced.eco/climate-governance/how-is-progress-in-chinas-1n-policy-framework/

Deting Li and Furong Jiao (2021). 'Review and prospect of the green certificate system under the background of "double carbon"', DeHeng Law Offices, https://www.dehenglaw.com/CN/tansuocontent/0008/022916/7.aspx?MID=0902

Fishman, D. (2022). *Reasons behind China's Power Shortage in Q4 2021, Resultant Reform Measures, and the Impact on Power Markets*, Oxford Institute for Energy Studies, March, https://www.oxfordenergy.org/publications/oxford-energy-forum-the-2021-energy-crisis-implications-for-chinas-energy-market-and-policies/

Fishman, D. (2023). 'Q&A: Chinese Green Energy Certificates (GECs)', Lantau Group, 9 August, https://www.lantaugroup.com/file/FAQ_China_Green_aug23.pdf

Fishman, D. and Zhang, J. (2021). 'Measures to accelerate and deepen power sector reforms announced in China', Lantau Group, 15 October, https://www.lantaugroup.com/file/brief_china_power_sector_oct21.pdf

Gan, N. (2023). 'Xi says China will follow its own carbon reduction path as US Climate Envoy Kerry meets top officials in Beijing', *CNN*, 18 July, https://www.cnn.com/2023/07/19/china/china-xi-carbon-climate-kerry-intl-hnk/index.html

Gardham, R. (2023). 'Deal focus: Why has Canadian solar taken a shine to Inner Mongolia?', *Investment Monitor*, 27 July, https://www.investmentmonitor.ai/news/deal-focus-why-has-canadian-solar-taken-a-shine-to-inner-mongolia/

Global Energy Monitor (2023). 'China poised to double wind and solar capacity five years ahead of 2030 target', *Global Energy Monitor*, 28 June, https://globalenergymonitor.org/press-release/china-poised-to-double-wind-and-solar-capacity-five-years-ahead-of-2030-target/

Gong Fang and Yuan Yuze (2023). 'China's green finance development will present ten important trends in 2023', *Xinhua Finance*, 30 August, http://www.tanjiaoyi.com/article-54229-1.html

Griggs, I. (2022). 'MingYang continues European Expansion with UK floating offshore wind deal', *Wind Power Monthly*, 22 September, https://www.windpowermonthly.com/article/1799644?utm_source=website&utm_medium=social

Guangdong DRC (2018). 'Notice No. 193', Guangdong Development and Reform Commission, 23 April, http://drc.gd.gov.cn/fzgh5637/content/post_845107.html

Guangdong DRC (2021). '14th five-year plan for the high-quality development of Guangdong's manufacturing industry', Guangdong Development and Reform Commission, http://www.gd.gov.cn/attachment/0/438/438152/3458543.pdf

Guangdong Energy Bureau (2022). 'Reply to the Proposal No. 20220634 of the Fifth Session of the Twelfth Provincial CPPCC', Guangdong Energy Bureau, 17 June, http://drc.gd.gov.cn/snyj/bmgl/content/post_3954359.html

GWEC (2016). *Global Wind Report: 2015*, Global Wind Energy Council, https://www.gwec.net/wp-content/uploads/vip/GWEC-Global-Wind-2015-Report_April-2016_22_04.pdf

Hayashi, D. (2020). 'Harnessing innovation policy for industrial decarbonization: Capabilities and manufacturing in the wind and solar power sectors of China and India', *Energy Research & Social Science*, 70, 101644, https://doi.org/10.1016/j.erss.2020.101644

Hefang Mu (2023). 'LONGi and Xi'an jointly played a "big game"', *Western Finance*, 17 March, https://www.china5e.com/news/news-1148915-1.html

Hongqiao Liu, Jianqiang Liu, and Xiaoying You (2021). 'Q&A: What does China's 14th 'Five Year Plan' mean for climate change?', *Carbon Brief*, 3 December, https://www.carbonbrief.org/qa-what-does-chinas-14th-five-year-plan-mean-for-climate-change/

Hove, A. (2023a). *Assessing China's Power Sector Low-Carbon Transition: A Framing Paper*, OIES Paper CE4, Oxford Institute for Energy Studies, https://www.oxfordenergy.org/wpcms/wp-content/uploads/2023/02/Assessing-Chinas-power-sector-low-carbon-transition-a-framing-paper-CE4.pdf

Hove, A. (2023b). *Synergies between China's Whole County PV Programme and Rural Heating Electrification*, OIES Paper CE6, Oxford Institute for Energy Studies, https://www.oxfordenergy.org/wpcms/wp-content/uploads/2023/05/CE6-Synergies-between-Chinas-Whole-County-PV-program-and-rural-heating-electrification.pdf

Hove, A. and Xie, G.S. (2023). *Green Certificates with Chinese Characteristics: Will Green Certificates Help China's Clean Energy Transition?*, OIES Paper CE9, Oxford Institute for Energy Studies, https://www.oxfordenergy.org/wpcms/wp-content/uploads/2023/08/CE9-Green-certificates-with-Chinese-characteristics.pdf

IEA (2021). *An Energy Sector Roadmap to Carbon Neutrality in China*, International Energy Agency, https://www.iea.org/reports/an-energy-sector-roadmap-to-carbon-neutrality-in-china

IEA (2023). *Building a Unified National Power Market System in China*, International Energy Agency, https://www.iea.org/reports/building-a-unified-national-power-market-system-in-china

Inner Mongolia New Energy Network (2022). 'Inner Mongolia Autonomous Region '14th Five-Year' Energy Development Plan', Inner Mongolia Development and Reform Commission, 8 March, https://www.nmgxny.com/policy/policy_20220308968.html

Jiangsu DRC (2022). 'Jiangsu Province 14th Five-Year Renewable Energy Development Special Plan', Jiangsu Development and Reform Commission, http://fzggw.jiangsu.gov.cn/attach/0/75525ce5a488407da252037b9de7510e.pdf

Jing Kang, Bin Hao, Yutong Li, Hui Lin, and Zhifeng Xue (2022). 'The application and development of LVDC buildings in China', *Energies*, 15(19), 7045, https://doi.org/10.3390/en15197045

Kuntze, J.-C. and Moerenhout, T. (2013). *Local Content Requirements and the Renewable Energy Industry – A Good Match?*, International Centre for Trade and Sustainable Development, https://unctad.org/system/files/non-official-document/DITC_TED_13062013_Study_ICTSD.pdf

Lixin Zhu and Ruisheng Sui (2021). 'Villagers embrace solar energy project in Shanxi', *China Daily*, 13 September, https://www.chinadaily.com.cn/a/202109/13/WS613ea40ea310efa1bd66ef09.html

Lu Min (2023). 'The "double carbon" goal promotes profound changes in the financial industry and financial institutions seize the green track', *Economic Daily*, 14 June, http://m.gxfin.com/article/finance/lc/default/2023-06-14/5996494.html

MEE (2021). 'Xi: China to release implementation plans to achieve carbon goals', China Ministry of Ecology and Environment, 12 October 12 https://english.mee.gov.cn/News_service/media_news/202110/t20211012_956262.shtml

Meidan, M. (2020). *Unpacking China's 2060 Carbon Neutrality Pledge*, Oxford Institute for Energy Studies, https://www.oxfordenergy.org/wpcms/wp-content/uploads/2020/12/Unpacking-Chinas-carbon-neutrality-pledge.pdf

Meidan, M. and Andrews-Speed, P. (2021). *China's Power Crisis: Long-Term Goals Meet Short-Term Realities*, Oxford Institute for Energy Studies, https://www.oxfordenergy.org/publications/chinas-power-crisis-long-term-goals-meet-short-term-realities/

Meidan, M., Hove, A., and Andrews-Speed, A. (2021*). Software versus Hardware: How China's Institutional Setting Helps and Hinders the Clean Energy Transition*, OIES Paper CE2, Oxford Institute for Energy Studies, https://www.oxfordenergy.org/wpcms/wp-content/uploads/2021/12/Software-versus-hardware-how-Chinas-institutional-setting-helps-CE2.pdf

Myllyvirta, L. (2020). 'China's 2060 climate pledge: Long-awaited breakthrough or sugar-coating another decade of rising emissions?', Centre for Research on Energy and Clean Air, 23 September, https://energyandcleanair.org/china-2060-carbon-neutrality/

Myllyvirta, L., Aiqin Yu, Champenois, F., and Xing Zhang (2023). 'China permits two new coal power plants per week in 2022', Centre for Research on Energy and Clean Air, Global Energy Monitor, 27 February, https://energyandcleanair.org/publication/china-permits-two-new-coal-power-plants-per-week-in-2022/

NDRC (2017a). 'Notice No. 132', National Development and Reform Commission, 3 February, http://www.gov.cn/xinwen/2017-02/03/content_5164836.htm

NDRC (2017b). ‘Notice on launching the pilot project for the construction of electricity spot market’, National Development and Reform Commission, 28 August, https://www.ndrc.gov.cn/xxgk/zcfb/tz/201709/t20170905_962552.html

NDRC (2019). ‘Notice of Renewable Energy Power Consumption Guarantee Mechanism’, National Development and Reform Commission, 10 May, https://www.ndrc.gov.cn/xxgk/zcfb/tz/201905/t20190515_962446.html

NDRC (2021a). ‘Responsibility weights for renewable energy electricity consumption in 2021 and related notices’, National Development and Reform Commission, 21 May, https://www.ndrc.gov.cn/xxgk/zcfb/tz/202105/t20210525_1280789.html

NDRC (2021b). ‘Notice No. 1439’, National Development and Reform Commission, 11 October, https://www.ndrc.gov.cn/xxgk/zcfb/tz/202110/t20211012_1299461.html

NDRC (2021c). ‘Action plan for carbon dioxide peaking before 2030’, National Development and Reform Commission, 27 October, https://en.ndrc.gov.cn/policies/202110/t20211027_1301020.html

NDRC. (2021d). ‘Reply letter on the pilot work plan for green power trading’, National Development and Reform Commission, 28 August, https://www.pvmeng.com/2021/08/28/21253/

NDRC (2022a). ‘Document No. 118’, National Development and Reform Commission, 18 January, https://www.ndrc.gov.cn/xxgk/zcfb/tz/202201/t20220128_1313653.html?code=&state=123

NDRC (2022b). ‘14th Five Year Plan for a Modern Energy System’, National Development and Reform Commission, 29 January, https://www.ndrc.gov.cn/xxgk/zcfb/ghwb/202203/t20220322_1320016.html

NDRC (2022c). ‘Document No. 208’, National Development and Reform Commission, 30 January, http://www.gov.cn/zhengce/zhengceku/2022-02/11/content_5673015.htm

NDRC (2022d). ‘Notice of the General Office of the National Development and Reform Commission and the General Division of the National Energy Administration on the responsibility weight of renewable energy electricity consumption in 2022 and related matters’, National Development and Reform Commission, 11 April, https://guangfu.bjx.com.cn/news/20221104/1266532.shtml

NDRC (2023a). ‘General Office of the National Development and Reform Commission General Office of the National Energy Administration about the electricity consumption of renewable energy in 2023 responsibility weight and notice of related matters’, National Development and Reform Commission, 16 July, https://www.ndrc.gov.cn/xwdt/tzgg/202308/t20230804_1359103_ext.html

NDRC (2023b). ‘Do a good job in the work of full coverage of renewable energy green power certificates: Notice on promoting renewable energy power consumption’, National Development and Reform Commission, 25 July, https://www.ndrc.gov.cn/xxgk/zcfb/tz/202308/t20230803_1359092.html

NDRC (2023c). ‘Notice of basic rules for electricity spot market (trial)’, National Development and Reform Commission, 7 September, https://www.ndrc.gov.cn/xxgk/zcfb/ghxwj/202309/t20230915_1360625_ext.html

NEA (2021). ‘Notice from the General Affairs Department of the National Energy Administration on submitting a pilot plan for rooftop distributed photovoltaic development in the entire county (city, district)’, National Energy Administration, 20 June, http://gdsolar.org/dongtaiinfo_1879.html

NEA (2022). ‘Circular No. 47’, National Energy Administration, 21 April, http://zfxxgk.nea.gov.cn/2022-04/21/c_1310587748.htm

People’s Daily (2014). ‘Xi: Actively promote China’s energy production and consumption revolution’, *People’s Daily*, 14 June, http://cpc.people.com.cn/n/2014/0614/c64094-25147885.html

People’s Daily (2023). ‘From small to large, from big to strong! Chronicle of Yangjiang offshore wind power industry development’, *People’s Daily*, 29 March, http://gd.people.com.cn/n2/2023/0329/c123932-40355664.html

Pickerel, K. (2023). ‘Trina Solar to build 5-GW solar panel factory in Texas’, *Solar Power World*, 11 September, https://www.solarpowerworldonline.com/2023/09/trina-solar-to-build-5-gw-solar-panel-factory-in-texas/

Polaris Carbon Steward (2022). ‘Beijing 2023 power trading (including green power) plan released for solicitation of comments’, *Polaris Carbon Steward*, 5 December, https://news.bjx.com.cn/html/20221205/1274194.shtml

Polaris Solar Photovoltaic (2022). ‘Enough is enough for the industrial support for new energy development!’, *Polaris Solar Photovoltaic*, 4 July, https://baijiahao.baidu.com/s?id=1737391854978913481&wfr=spider&for=pc

Polaris Solar Photovoltaic (2023). ‘LONGi Green Energy’s annual production of 100GW of monocrystalline silicon wafers and 50GW of monocrystalline cells has landed in Xixian New Area, Shaanxi’, *Polaris Solar Photovoltaic*, 17 January, https://guangfu.bjx.com.cn/news/20230117/1283736.shtml

Pontecorvo, E. (2020). ‘Can China go net-zero? Two charts show just how ambitious Xi Jinping’s goal is’, *Grist*, 2 October, https://grist.org/climate/can-china-go-net-zero-two-charts-show-just-how-ambitious-xi-jinpings-goal-is/

Qingru Ma, Jinzhu Zhou, and Peng Du (2020). ‘In 2020, LONGi will deploy these three major projects in Shaanxi’, *West Net News*, 14 July, http://m.cnwest.com/zwyw/a/2020/07/14/18926467.html

Rapoza, K. (2023). ‘China solar companies qualify for benefits under Inflation Reduction Act’, *Forbes*, 24 February, https://www.forbes.com/sites/kenrapoza/2023/02/24/china-solar-companies-qualify-for-benefits-under-inflation-reduction-act/

Shandong Province Energy Administration (2022). ‘March 3 Press Conference: Shandong Provincial Government Information Office’, Shandong Province Energy Administration, 4 March, http://nyj.shandong.gov.cn/art/2022/3/4/art_59979_10292533.html

Shaw, V. (2021). ‘China set to mandate solar on at least 20% of residential roofs in pilot counties’, pv magazine, 1 July, https://www.pv-magazine.com/2021/07/01/china-set-to-mandate-solar-on-at-least-20-of-residential-roofs-in-pilot-counties/

Sivaram, V. (2018). *Taming the Sun: Innovations to Harness Solar Energy and Power the Planet*, MIT Press, https://doi.org/10.7551/mitpress/11432.001.0001

Sohu.com (2022). ‘Xi’an 14th Five-Year Plan for Industrial and Information Development’, Xi’an Municipal Government, 24 October, https://www.sohu.com/a/595037615_626579

Sohu.com (2023). ‘The latest summary of China’s dual-carbon ‘1+N’ policy system in 2023’, *Carbon Neutral Download*, 4 May, https://www.sohu.com/a/672674502_484815

Song Gu *et al.* (2022). ‘Development trend and suggestions of China’s offshore wind power equipment industrial park/base’, *Wind Energy Magazine*, 7 November, https://news.bjx.com.cn/html/20221107/1266681.shtml

State Council (2015). ‘Opinions of the Central Committee of the Communist Party of China and the State Council on further deepening the reform of the electric power system’, Central Committee of the Communist Party of China, State Council, 10 April, https://m.bjx.com.cn/mnews/20150410/606700.shtml

State Council Information Office (2023). ‘Xi urges Inner Mongolia to pursue green development, advance Chinese modernization’, *Xinhua*, 8 June, http://english.scio.gov.cn/topnews/2023-06/08/content_86706975.htm

Sufang Zhang and Yongxiu He (2013). ‘Analysis on the development and policy of solar PV power in China’, *Renewable and Sustainable Energy Reviews*, 21, 393–401, https://doi.org/10.1016/j.rser.2013.01.002

Trina Solar (2022). 'Trina Solar signed a strategic cooperation agreement with the Qinghai Provincial Government to jointly build a "source, grid, load and storage integrated zero-carbon industrial park"', Trina Solar, 14 March, https://www.trinasolar.com/cn/resources/newsroom/mon-03142022-1536

Waite, N. (2022). *Chinese Offshore Wind Goes Global*, Institute for Energy Economics and Financial Analysis, 5 September, https://ieefa.org/resources/chinese-offshore-wind-goes-global

Waldersee, V. (2023). 'Politics aside, China's CATL ramps up cell production in Germany', *Reuters*, 27 January, https://www.reuters.com/technology/chinas-catl-german-plant-targets-six-battery-cell-production-lines-by-end-2023-2023-01-26/

Weixin (2023). 'LONGi hydrogen helps China's first 10,000-ton green hydrogen demonstration project to be fully put into operation', LONGi Hydrogen Energy, 30 August, https://mp.weixin.qq.com/s/rfC5BDAM1U8A3ynC591vcw

Wood Mackenzie (2023). 'China's solar exports booming, up 64% in 2022 despite global trade tensions', Wood Mackenzie, 23 May, https://www.woodmac.com/press-releases/chinas-solar-exports-booming-up-64-in-2022-despite-global-trade-tensions/

Xi Jinping (2020). 'Full text: Xi Jinping's Speech at the General Debate of the 75th Session of the United Nations General Assembly', CGTN, 9 September, https://news.cgtn.com/news/2020-09-23/Full-text-Xi-Jinping-s-speech-at-General-Debate-of-UNGA-U07X2dn8Ag/index.html

Xi Lu, Shaojun Zhang, Jia Xing, Yunjie Wang, Wenhui Chen, Dian Ding, Ye Wu, Shuxiao Wang, Lei Duan, and Jiming Hao (2020). 'Progress of air pollution control in china and its challenges and opportunities in the ecological civilization era', *Engineering*, 6(12), 1423–1431, https://doi.org/10.1016/j.eng.2020.03.014

Xiaoli Zhao, Shujie Li, Sufang Zhang, Rui Yang, and Suwei Liu (2016). 'The Effectiveness of China's Wind Power Policy: An Empirical Analysis', *Energy Policy* 95 (August): 269–79, https://doi.org/10.1016/j.enpol.2016.04.050

Xiaoying You (2023). 'Two sessions: Chinese provinces push for coal and clean energy', *China Dialogue*, 1 March, https://chinadialogue.net/en/energy/two-sessions-chinese-provinces-push-coal-and-clean-energy/

Xinhua News Agency (2021a). 'The 14th Five-Year Plan for National Economic and Social Development of the People's Republic of China and the outline of long-range goals for 2035', *Xinhua News Agency*, 12 March, https://www.gov.cn/xinwen/2021-03/13/content_5592681.htm

Xinhua News Agency (2021b). 'Han Zheng chaired the first plenary meeting of the leading group for carbon peak and carbon neutrality work and delivered a speech', *Xinhua News Agency*, 27 May, https://www.gov.cn/guowuyuan/2021-05/27/content_5613268.htm

Xinhua News Agency (2022). '"It is necessary to establish first and then destroy, but not to destroy before it is established": Correctly understand and grasp the "double carbon" goal from the perspective of the national two sessions', *Xinhua News Agency*, 8 March, https://www.gov.cn/xinwen/2022-03/08/content_5677839.htm

Xinhuanet (2021). 'China to control, phase down coal consumption in next decade: Xi', *Xinhua*, 22 April, http://www.xinhuanet.com/english/2021-04/22/c_139899306.htm

Yang, K., Schot, J., and Truffer, B. (2022). 'Shaping the directionality of sustainability transitions: The diverging development patterns of solar photovoltaics in two Chinese provinces', *Regional Studies*, 56(5), 751–769, https://doi.org/10.1080/00343404.2021.1903412

Yixiu Wu (2019). 'Is coal power winning the US–China trade war?', *China Dialogue*, 12 November, https://chinadialogue.net/en/energy/11642-is-coal-power-winning-the-us-china-trade-war/

Yu Chen (2015). *EU–China Solar Panels Trade Dispute: Settlement and Challenges to the EU*, European Institute for Asian Studies, https://eias.org/wp-content/uploads/2016/02/EU-Asia-at-a-glance-EU-China-Solar-Panels-Dispute-Yu-Chen.pdf

Yu Wang, Jijiang He, and Wenying Chen (2021). 'Distributed solar photovoltaic development potential and a roadmap at the city level in China', *Renewable and Sustainable Energy Reviews*, 141, 110772, https://doi.org/10.1016/j.rser.2021.110772

Zhandong Wang (2023). 'Projects are accelerating and industries are speeding up and improving quality: Gansu accelerates the development of new energy industry', *Gansu Daily*, 8 January, http://gansu.gansudaily.com.cn/system/2023/01/08/030696214.shtml

Zhang, J. and Fishman, D. (2022). 'Green power trading to accelerate in China', Lantau Group, 5 May, https://www.lantaugroup.com/file/brief_china_green_power_may22.pdf

Zheng Xin and Yuan Hui (2022). 'Landmark net-zero industrial park taking shape', *China Daily*, 1 September, https://global.chinadaily.com.cn/a/202209/01/WS630fed27a310fd2b29e7549c.html

Zhijian Xia (2022). 'China's power system needs to modernise', *China Dialogue*, 8 November, https://chinadialogue.net/en/energy/chinas-power-system-needs-to-modernise/

Zhou, C., Zhang, R., Loginova, J., Sharma, V., Zhang, Z., and Qian, Z. (2022). 'Institutional logic of carbon neutrality policies in China: What can we learn?', *Energies*, 15(12), 4391. https://doi.org/10.3390/en15124391