NOTE

THE CASE FOR A GREEN PACT: HOW THE GROUP OF 20 CAN WIELD THE POWER OF GREEN SUBSIDIES LIKE CHINA'S SOLAR INDUSTRY

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ABSTRACT

Few trade relationships will determine the pace and outcome of the global energy transition more than the world's relationship with China and its manufacturers of clean energy technologies. The role of the Chinese state in the rise and dominance of its domestic producers across the solar photovoltaic supply chain embodies the country's controversial but effective use of subsidies and other supports to promote the clean-economy industries China perceives as its future: electric vehicles, batteries, and solar. While other economies in the Group of 20 have sought to grow these industries in their own markets, several—including the United States—have done so in part by increasing tariffs on importers of Chinese-made clean energy products. These measures often accompany allegations that China has impermissibly subsidized such products and injured domestic producers in the nation imposing tariffs. To escape a climate-negative doom loop of trade conflict wherein geopolitical rivals raise barriers to each other's green goods ever higher, this Note proposes a "Green Pact" among G20 countries. Taking lessons from China's successful support of its solar photovoltaic manufacturers, a Green Pact would preclude retaliation against foreign green subsidies, encouraging members instead to support production of low- or zero-carbon energy-intensive trade-exposed goods and clean energy products. By making qualifying subsidies non-actionable, a Green Pact would seek to use trade tools to help, not hinder, a just transition, with benefits for least-developed countries and rich countries alike.

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I. INTRODUCTION

In 2001, when China acceded to the World Trade Organization (WTO), solar photovoltaic (PV) modules cost about five USD per watt,[1] and China produced just one percent of the world's solar panels.[2] A quarter-century hence, China enjoys peerless control of solar

1. *Evolution of Solar PV Module Cost by Data Source, 1970-2020*, INT'L ENERGY AGENCY (July 2, 2020), https://www.iea.org/data-and-statistics/charts/evolution-of-solar-pv-module-cost-by-data-source-1970-2020.

2. Lei Zhu et al., *Enabled Comparative Advantage Strategy in China's Solar PV Development*, 133 ENERGY POL'Y, Oct. 2019, at 2, https://www.sciencedirect.com/science/article/abs/pii/S0301421519304586.

production and deploys more solar energy annually than the rest of the world combined.[3] Today, eighty percent of the world's solar manufacturing capacity is in China,[4] where exploding capacity has helped drive PV module prices down to roughly 0.08 USD per watt.[5] If anything, this understates China's dominance in the solar industry, since China controls even greater shares of certain inputs: China produces ninety-one percent of the world's polysilicon for solar wafers (which China makes at half the U.S. price) and ninety-seven percent of the world's solar ingots and wafers (the United States makes none).[6] China's solar panels are also thirty to forty percent cheaper than U.S. panels and twenty-five to forty-five percent cheaper than EU panels.[7] Chinese producers can manufacture "almost a terawatt of renewable-energy capacity in a year," nearly twice as much capacity as the United States and Europe have combined.[8] China has deployed renewables at similar scale: In the first half of 2025, China installed more PV capacity than the United States has in history.[9]

China's solar miracle is an optimistic case study for the energy transition and the fight against climate change. The world has perhaps never had so much certainty about the dangers of climate change,[10] so much

3. *Global solar installations surge 64% in first half of 2025*, EMBER (Sep. 2, 2025), https://ember-energy.org/latest-updates/global-solar-installations-surge-64-in-first-half-of-2025/.

4. Isabel Hilton, *How China Became the World's Leader on Renewable Energy*, YALE ENV'T 360 (Mar. 13, 2024), https://e360.yale.edu/features/china-renewable-energy.

5. Oil Price Information Service, *FOB China solar panel prices climb amid concerns about delinking with market fundamentals*, PV MAGAZINE (July 25, 2025), https://www.pv-magazine.com/2025/07/25/fob-china-solar-panel-prices-climb-amid-concerns-about-delinking-with-market-fundamentals; Anu Bhambhani, *Solar PV Module Prices Projected To Rise 9% In Q4 2025*, TAIYANG NEWS (Oct. 3, 2025, at 6:10 AM), https://taiyangnews.info/business/solar-module-prices-projected-to-rise-9-percent-in-q4-2025.

6. *See* Phred Dvorak & Andrew Mollica, *Can the U.S. Break China's Grip on Solar?*, WALL ST. J. (Feb. 13, 2024, 12:31 AM), https://www.wsj.com/business/can-the-u-s-break-chinas-grip-on-solar-18837af6.

7. *See* Keith Bradsher, *How China Came to Dominate the World in Solar Energy*, N.Y. TIMES (Mar. 8, 2024), https://www.nytimes.com/2024/03/07/business/china-solar-energy-exports.html.

8. *China's Clean-Energy Revolution Will Reshape Markets and Politics*, THE ECONOMIST (Nov. 6, 2025), https://www.economist.com/leaders/2025/11/06/chinas-clean-energy-revolution-will-reshape-markets-and-politics.

9. Current total U.S. solar capacity is measured at 255.4 GW while China installed 256 GW in the first half of 2025. *See* EMBER, *supra* note 3; *Q3 2025 Solar Market Insight Report*, SOLAR ENERGY INDUS. ASS'N (Sept. 8, 2025), https://seia.org/research-resources/us-solar-market-insight/.

10. *See generally* Adrien Bilal & Diego R. Känzig, *The Macroeconomic Impact of Climate Change: Global vs. Local Temperature* 1 (Nat'l Bureau of Econ. Rsch., Working Paper No. 32450, 2024) (finding that a 1˚C increase in global temperature leads to a 12% decline in world GDP; the Social Cost of Carbon is $1,367 per ton of carbon dioxide; and a business-as-usual warming scenario

reason to believe we can stay below two and a half degrees Celsius of global warming,[11] and so little time to achieve that goal. With few areas of the green transition going anywhere near as well as solar deployment, China's solar success showcases an array of effective policy tools for global decarbonization.[12]

Unfortunately, China's example is also fraught with risks, both present and future, and China's pro-solar industrial policy has long run afoul of international trade rules, drawing foreign competitors' ire. Deindustrialization in the United States and the European Union has led leaders there to blame China. For the solar industry at least, their claims have merit: China's solar industry eviscerated the competition in part through violations of WTO rules on subsidies. In recent years, the United States has employed anti-subsidy measures to protect its remaining solar PV producers, including overwhelming tariffs on U.S. imports of certain solar products from China and other Southeast Asian countries where Chinese PV producers operate.[13] Observers have noted, however, that "American officials may be worried that a China-dominated supply chain could restrict the flow of solar panels and raise costs for clean energy in the future, but their solution [of increased tariffs] is doing that now."[14]

In short, protectionism in the West has made clean energy more expensive there in recent years, slowing efforts to decarbonize the power sector and contributing somewhat to several years of high inflation.[15]

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leads to a present value welfare loss of 25%, implying that unilateral decarbonization policy is cost-effective for large countries such as the United States).

11. *See* Thomas Bossy et al., *On the Chances of Staying Below the 1.5°C Warming Target*, CELL REPS. SUSTAINABILITY, July 26, 2024, at 4; *see also generally* HANNAH RITCHIE, NOT THE END OF THE WORLD: HOW WE CAN BE THE FIRST GENERATION TO BUILD A SUSTAINABLE PLANET (2024) (describing paths to carbon neutrality).

12. *See generally* IGNACIO BANARES-SANCHEZ ET AL., CHINESE INNOVATION, GREEN INDUSTRIAL POLICY AND THE RISE OF SOLAR ENERGY (2024) (discussing the relative success of Chinese solar in the energy transition).

13. *See* Mark Chediak & Jennifer Dlouhy, *US Imposes Tariffs Up to 3521% on Asian Solar Imports*, BLOOMBERG (Apr. 21, 2025, at 17:03 ET), https://www.bloomberg.com/news/articles/2025-04-21/us-imposes-new-duties-on-solar-imports-from-southeast-asia.

14. Dan Murtaugh, *Market Forces, Not Words, Can Fix China's Solar Overcapacity*, BLOOMBERG (Apr. 9, 2024, at 7:21 ET), https://www.bloomberg.com/news/newsletters/2024-04-09/china-s-solar-manufacturing-boom-market-forces-not-words-can-fix-overcapacity ("Only in EVs and to some extent solar panels—where rapid technology switches are likely to lead to many production lines getting shuttered in the years ahead—are proposed capacities running ahead of what the world needs if we're to transition to a net-zero economy.").

15. *See* Katheryn Russ, *Tariffs on Chinese Imports Have Only Marginally Contributed to US Inflation*, PETERSON INST. FOR INT'L ECON. (Jan. 13, 2022), https://www.piie.com/research/piie-charts/tariffs-chinese-imports-have-only-marginally-contributed-us-inflation. US protectionism has been

Still, the United States has reason to oppose a global solar supply chain located entirely in China: Such Chinese dominance leaves the world's PV supply vulnerable to public health shocks like the COVID-19 pandemic, threatens U.S. energy security in a decarbonizing world, and exposes global solar consumers to fluctuations in Chinese industrial policy in a volatile and intensely competitive industry.[16] The United States may have more success if it stops treating tariffs like a protectionist panacea and starts playing the game more like China.

This Note will thus argue that policymakers should, instead of fighting China's solar miracle, adopt China's strategy while entering a "Green Pact," wherein Group of 20 (G20) governments accept each other's climate-positive subsidies and adopt mutually binding rules that would make such subsidies presumptively non-actionable. Global cooperation in the fight against climate change will require state intervention to kickstart or grow the industries needed for a zero-emissions future. Green energy and manufacturing must grow at a pace that no single country can achieve on its own. The supply chain for green energy must also span the whole world—and receive state support almost everywhere possible. Trade law will thus need to allow countries to adopt generous incentives for domestic green industry.

To understand how trade law can support the fastest possible decarbonization, this Note will take the case study of China's dominance in solar manufacturing and draw lessons for how the rest of the world can spur growth in clean industries. Part II explains how China came to dominate solar PV manufacturing and why China remains dominant before Part III examines the costs and benefits of the solar status quo. Part IV makes recommendations about how to rewrite subsidy rules for the G20 to establish a Green Pact and help major economies adopt ambitious policy regimes, aiming to harness the best and limit the worst of China's subsidy-fueled solar story by reinventing subsidy disciplines for an era of climate crisis.

more significant and ongoing, whereas the EU has not imposed tariffs on Chinese solar since it lifted them in 2018. *See* Alice Hancock, *Europe's Solar Industry Warns of Bankruptcies Over Chinese Imports*, FIN. TIMES (Sep. 11, 2023), https://www.ft.com/content/8885e301-0956-44f1-bb5c-9141d0c7be9c.

16. *See, e.g.*, *Top Solar Firm Longi Plans Thousands of Job Cuts on Glut*, BLOOMBERG (Mar. 18, 2024, at 04:20 ET), https://www.bloomberg.com/news/articles/2024-03-18/world-s-top-solar-firm-longi-plans-thousands-of-job-cuts-on-glut.

II. How China Came to Dominate Solar PV Manufacturing and Why It Still Does

What makes China's dominance particularly impressive is the length and complexity of the solar PV supply chain, which China controls end-to-end. Much of the labor-intensive mining of raw materials like silicon occurs in provinces such as Yunnan and the autonomous region of Xinjiang,[17] while other provinces perform more automated stages of production like refining polysilicon, converting polysilicon into solar ingots, and slicing ingots into the microscopic wafers used in solar cells.[18] China's share of global polysilicon, ingot, and wafer production is soon expected to approach ninety-five percent,[19] and in recent years, China has produced more than ninety percent of the world's solar cells.[20] Final assembly of solar panels, eighty-three percent of which are made in China, is among the few stages of the solar supply chain where China's dominance is not total.[21]

Twenty-five years ago, however, China was a low-income country largely devoid of advanced manufacturing, and it was arriving to the solar industry decades behind the PV powerhouse of the time, the United States.[22] Only since its 2001 WTO accession has China leveraged its comparative advantages to dominate the solar supply chain, using cheap labor, subsidies, forced technology transfers, and stolen intellectual property (IP) to achieve economies of scale before selling into lucrative foreign markets.[23]

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17. *Everything You Need to Know About China's Industrial Silicon Market,* Shanghai Metals Mkt. (Feb. 5, 2023, at 22:16 ET), https://news.metal.com/newscontent/102084821/Everything-You-Need-to-Know-about-China's-Industrial-Silicon-Market/.

18. *See* U.S. Dep't of Energy, Solar Photovoltaics Supply Chain Deep Dive Assessment 11 (2022).

19. Int'l Energy Agency, Solar PV Global Supply Chains 9 (2022), https://www.iea.org/reports/solar-pv-global-supply-chains.

20. Int'l Energy Agency Photovoltaic Power Systems Programme, Trends in Photovoltaic Applications 53 (2024), https://iea-pvps.org/wp-content/uploads/2025/10/IEA-PVPS_Trends_2025-.pdf.

21. Dvorak & Mollica, *supra* note 6.

22. *See, e.g.*, David Fickling, *How the US Lost the Solar Power Race to China*, Bloomberg (Sep. 30, 2024), https://www.bloomberg.com/graphics/2024-opinion-how-us-lost-solar-power-race-to-china/.

23. *See, e.g.*, Benjamin Jensen, *How the Chinese Communist Party Uses Cyber Espionage to Undermine the American Economy*, Ctr. for Strategic & Int'l Stud. (Oct. 19, 2023), https://www.csis.org/analysis/how-chinese-communist-party-uses-cyber-espionage-undermine-american-economy; *see also* Yudhijit Bhattacharjee, *The Daring Ruse That Exposed China's Campaign to Steal American Secrets*, N.Y. Times Mag. (June 15, 2023), https://www.nytimes.com/2023/03/07/magazine/china-spying-intellectual-property.html (discussing Chinese corporate espionage).

A. *China's Share of Global Solar Manufacturing Began to Grow Due to Low Labor Costs, Economies of Scale, Domestic Competition, and Investments in Inputs*

To become a solar juggernaut, China made the most of its comparative advantages. In 2002, manufacturing workers in China earned an average of 0.57 USD per hour,[24] whereas American manufacturing workers earned about fifteen USD per hour.[25] Such low labor costs allowed Chinese solar producers to grow quickly at a time when the industry was less automated.[26] As their explosive growth surpassed that of U.S. and European rivals, Chinese manufacturers benefited from a burgeoning (if saturated) domestic market and unrivaled economies of scale, which in turn allowed greater "learning by doing" and reduced fixed and soft costs.[27] Together, these factors allowed China to close the gap between its solar producers and better-established producers in the United States and Germany.[28]

In an industry where scale and automation are pivotal, China spent the late 2000s and early 2010s building bigger, more automated, and more sophisticated solar PV factories, thereby overtaking the U.S. market on price and quality even as labor costs rose.[29] Chinese city and provincial governments competed to attract solar producers with tax incentives, cheap land, and investments.[30] Government funding for research and development (R&D) of at least 300 million USD also helped catalyze more than 1.4 billion USD in private solar R&D from

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24. Judith Banister, *Manufacturing Earnings and Compensation in China*, 128 MONTHLY LAB. REV. 22, 22 (Aug. 2005).

25. *Average Hourly Earnings of Production and Nonsupervisory Employees, Manufacturing*, FED. RSRV. BANK OF ST. LOUIS, https://fred.stlouisfed.org/series/CES3000000008 (last visited Apr. 13, 2024).

26. *See The Solar-Powered Future Is Being Assembled in China*, BLOOMBERG (Sep. 14, 2020, at 17:00 ET), https://www.bloomberg.com/features/2020-china-solar-giant-longi/; *see also* INT'L ENERGY AGENCY, *supra* note 19, at 10, 35, 46, 94-95 (noting how cheap labor and, later, automation have helped increase PV production).

27. *See* Yassine Lefouili & Claude Crampes, *Learning by Doing in the Solar Panel Industry*, TOULOUSE SCH. OF ECON. (Sep. 18, 2018), https://www.tse-fr.eu/learning-doing-solar-panel-industry; *see also* INT'L ENERGY AGENCY, *supra* note 19 (describing, *inter alia*, how Chinese manufacturers leveraged economies of scale to cut prices and increase PV market share); BANARES-SANCHEZ ET AL., *supra* note 12, at 12-13, 36, OA-7 to OA-9 (describing how Chinese learning-by-doing patents improved productivity).

28. Kevin Bullis, *Solar's Great Leap Forward*, MIT TECH. REV. (June 22, 2010), https://www.technologyreview.com/2010/06/22/202348/solars-great-leap-forward/.

29. *See* John Fialka, *Why China Is Dominating the Solar Industry*, SCI. AM. (Dec. 19, 2016), https://www.scientificamerican.com/article/why-china-is-dominating-the-solar-industry/.

30. BANARES-SANCHEZ ET AL., *supra* note 12, at 7.

2001 to 2015.[31] Strategic investment in the full solar supply chain—including strategic but also lucky R&D decisions that allowed Chinese producers to benefit from plunging silicon prices in the late 2000s—also helped China secure domestic supplies of raw materials such as polysilicon as it mined and processed an increasing share.[32] Such investments paid off: Between 2004 and 2008, China's solar production grew sixfold to a third of global output.[33] The rapid growth of China's solar industry meant that by 2008, Chinese producers also faced strong domestic competition, making them ever more competitive internationally as global PV output boomed.[34] By 2012, domestic sales were surging, and China's solar industry was the world's largest.[35]

B. *Chinese Solar Production Further Expanded Due to Foreign and Domestic Subsidies, Producers' Intellectual Property Theft, and Forced Technology Transfers*

To cement its dominance, China combined strategic subsidies, opportunism, and forced IP transfer and gave its solar industry increasing pride of place from the Eleventh Five-Year Plan (2006 to 2010) through the Thirteenth Five-Year Plan (2016 to 2020).[36] To cement its dominance, China combined strategic subsidies, opportunism, and forced IP transfer and gave its solar industry increasing pride of place from the Eleventh Five-Year Plan (2006 to 2010) through the Thirteenth Five-Year

31. *See* JEFFREY BALL ET AL., THE NEW SOLAR SYSTEM: CHINA'S EVOLVING SOLAR INDUSTRY AND ITS IMPLICATIONS FOR COMPETITIVE SOLAR POWER IN THE UNITED STATES AND THE WORLD 96-97 (2017).

32. *See* Ajay Gambhir et al., *The Impact of Policy on Technology Innovation and Cost Reduction: A Case Study on Crystalline Silicon Solar PV Modules* 12 (Imperial Coll. London, Working Paper, 2014), https://www.imperial.ac.uk/media/imperial-college/grantham-institute/public/publications/working-papers/The-impact-of-policy-on-technology-innovation-and-cost-reduction-WP.pdf; INT'L ENERGY AGENCY, *supra* note 19, at 17-23 (describing China's increasing share of global polysilicon refining and production).

33. *Land of the Rising Subsidy*, ECONOMIST (Aug. 27, 2009), https://www.economist.com/business/2009/08/27/land-of-the-rising-subsidy.

34. MATTHEW HOPKINS & YIN LI, CHINA AS AN INNOVATION NATION 306-32 (Yu Zhou et al. eds., 2016).

35. Bruce Einhorn, *Firing Up China's Solar Market*, BLOOMBERG (Mar. 15, 2012, at 14:03 ET), https://www.bloomberg.com/news/articles/2012-03-15/firing-up-chinas-solar-market.

36. *See* BANARES-SANCHEZ ET AL., *supra* note 12, at 5. Five-year plans are China's budgetary and economic plans, which lay out the Communist Party's goals for centralized economic management in five-year increments. *See What Is China's Five-Year Plan?*, ECONOMIST (Mar. 4, 2021), https://www.economist.com/the-economist-explains/2021/03/04/what-is-chinas-five-year-plan.

Plan (2016 to 2020).[37] Chinese PV output grew because of improving technology (some allegedly stolen[38] and some invented by Chinese producers), cheap financing, and generous subsidies—though China was far from the sole government subsidizing solar. Germany, for instance, provided solar feed-in tariffs, which provide a guaranteed above-market power price to encourage deployment of renewable energy.[39] Because German feed-in tariffs primarily incentivized PV *generation*, not *manufacturing*, they encouraged installation of the cheapest solar modules, which, much to China's benefit, were those of Chinese producers by the late 2000s.[40] German feed-in tariffs, followed by similar incentives in Spain and Italy, thus drew huge volumes of Chinese solar panels into the European market, where Chinese manufacturers quickly dominated.[41] Success in Germany spurred Chinese solar producers to focus on exports to take advantage of foreign subsidies, particularly amid high domestic competition and low domestic prices.[42] Because the Chinese PV industry was not yet mature in the late 2000s, foreign subsidies catalyzed a self-reinforcing, boom-and-bust cycle of expanded

37. *See* BANARES-SANCHEZ ET AL., *supra* note 12, at 5. Five-year plans are China's budgetary and economic plans, which lay out the Communist Party's goals for centralized economic management in five-year increments; ECONOMIST, *supra* note 36.

38. China has long faced allegations of corporate espionage and theft of intellectual property, but such claims have often been hard to litigate or prove without extradition of defendants. *See, e.g.*, Michael S. Schmidt & David E. Sanger, *5 in China Army Face Charges of Cyberattacks*, N.Y. TIMES (May 19, 2014), https://www.nytimes.com/2014/05/20/us/us-to-charge-chinese-workers-with-cyberspying.html. Besides outright hacking, China has employed various coercive means of obtaining foreign intellectual property, including forced technology transfers and obligations for foreign companies to partner and share designs with Chinese firms. *See* Lingling Wei & Bob Davis, *How China Systematically Pries Technology From U.S. Companies*, WALL ST. J. (Sep. 26, 2018, at 10:27 ET), https://www.wsj.com/articles/how-china-systematically-pries-technology-from-u-s-companies-1537972066; *see also* Keith Bradsher, *How China Obtains American Trade Secrets*, N.Y. TIMES (Jan. 15, 2020), https://www.nytimes.com/2020/01/15/business/china-technology-transfer.html; *see generally* OFF. U.S. TRADE REPRESENTATIVE, FOUR-YEAR REVIEW OF ACTIONS TAKEN IN THE SECTION 301 INVESTIGATION: CHINA'S ACTS, POLICIES, AND PRACTICES RELATED TO TECHNOLOGY TRANSFER, INTELLECTUAL PROPERTY, AND INNOVATION 3, 21-51 (2024) (documenting investigations into China's methods of acquiring foreign technology and intellectual property).

39. *Feed-in tariff: A Policy Tool Encouraging Deployment of Renewable Electricity Technologies*, U.S. ENERGY INFO. ADMIN. (May 30, 2013), https://www.eia.gov/todayinenergy/detail.php?id=11471.

40. UNITED NATIONS CONFERENCE ON TRADE & DEV., SCIENCE, TECHNOLOGY AND INNOVATION POLICY REVIEW: GERMANY 24–26 (2018) (describing how German feed-in tariffs created a guaranteed and more profitable market for PV panels as China's export-oriented PV industry rapidly grew its export capacity, "result[ing] in a rapid uptake of installations in Germany"); pvXchange, *Snapshot of Spot Market for PV Modules – Quarterly Report Q4 2009*, 7 PHOTOVOLTAICS INT'L 145-46 (2010).

41. *See* UNITED NATIONS CONFERENCE ON TRADE & DEV., *supra* note 40.

42. *Id.*

Chinese production capacity and price cuts, whereby manufacturers raced to build ever-larger facilities and thus outcompete rivals through superior economies of scale.

The Chinese government also invested hundreds of billions of dollars in its solar industry at an accelerating rate, with thirty billion USD in state support in 2010,[43] its own domestic feed-in tariff in 2011 as foreign markets eroded,[44] more than fifty billion USD in subsidies between 2011 and 2021 (at least ten times more than the EU),[45] and 130 billion USD invested in 2023 alone.[46] After initially leading with production and innovation subsidies, Chinese cities in 2013 began to favor demand subsidies, which have been the most common type of subsidy over the past decade.[47] The Chinese Development Bank (CDB), a "policy bank" created to facilitate China's industrial policy, also furnished domestic solar manufacturers with below-market-rate loans and other kinds of "free money" in the 2000s and 2010s.[48] After taking advantage of cheap labor in their early years, Chinese solar producers in the early 2010s used these CDB loans and subsidies to make the capital expenditures needed to automate production. China's subsidies to solar producers were so essential that experts estimate the country's six largest producers, which had debt ratios of more than eighty percent in 2012, would have gone bankrupt without them.[49]

Beyond subsidies, Chinese solar manufacturers improved products by stealing or reverse-engineering foreign solar intellectual property (e.g. wafer and cell designs) before developing their own original designs—a Chinese economic strategy typical of the era.[50] And while Chinese solar producers' R&D expenditures and innovation have since slowed, with most favoring production capacity over greater conversion efficiency, China's solar manufacturers enjoyed ample research budgets in the years

43. Einhorn, *supra* note 35.

44. Liang-Cheng Ye, João F.D. Rodrigues & Hai Xiang Lin, *Analysis of Feed-in Tariff Policies for Solar Photovoltaic in China 2011–2016,* 203 APPLIED ENERGY 496 (2017).

45. INT'L ENERGY AGENCY, *supra* note 19, at 7, 48.

46. *China to Hold Over 80% of Global Solar Manufacturing Capacity from 2023-26*, WOOD MACKENZIE (Nov. 7, 2023), https://www.woodmac.com/press-releases/china-dominance-on-global-solar-supply-chain/.

47. *See* BANARES-SANCHEZ ET AL., *supra* note 12, at 9. Demand subsidies include, for instance, subsidies for the installation of solar panels. *Id.* at 8.

48. Stephen Lacey, *How China Dominates Solar Power*, GUARDIAN (Sept. 12, 2011, at 09:10 ET), https://www.theguardian.com/environment/2011/sep/12/how-china-dominates-solar-power.

49. Usha C.V. Haley & George T. Haley, *How Chinese Subsidies Changed the World*, HARV. BUS. REV. (Apr. 25, 2013), https://hbr.org/2013/04/how-chinese-subsidies-changed.

50. *See* Jensen, *supra* note 23; *see also* Bhattacharjee, *supra* note 23 (discussing Chinese corporate espionage).

spent working to compete with U.S. and German designs.[51] Before China's solar panels truly rivaled Western technologies and the solar PV industry matured into the highly commoditized market it is today, Chinese PV producers succeeded primarily by providing a slightly inferior product at a superior price.

C. *China Still Dominates the Solar Supply Chain Due to Vertical Integration, Consistent Policy Supports, and Domestic Technological Innovation*

By the mid-2010s, Chinese solar manufacturers produced most of the world's solar raw materials, solar ingots and wafers, solar cells, and solar panels, all for less than their U.S. and European counterparts despite their comparable quality. In the decade since, as Western governments withdrew many of their policy supports for solar,[52] China largely maintained its subsidies; only since 2021 has China begun to phase out its solar PV feed-in tariff, for instance.[53] Consequently, China has cemented its dominance over the past decade even as its domestic labor costs have begun to rise and solar manufacturing has grown ever more competitive. Today, China retains its status as the world's solar factory via industrial policy, market consolidation, vertical integration, successful investments, and technological innovation.

China's domestic labor costs, no longer central to its solar success, have risen but remain low at roughly a third of U.S. wages.[54] China's subsidies for solar production have also been steadier than, for instance, the U.S. solar Investment Tax Credit over the past twenty years, [55] giving Chinese producers predictability when deciding to invest in production capacity.

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51. David M. Hart, *The Impact of China's Production Surge on Innovation in the Global Solar Photovoltaics Industry*, INFO. TECH. & INNOVATION FOUND. (Oct. 5, 2020), https://itif.org/publications/2020/10/05/impact-chinas-production-surge-innovation-global-solar-photovoltaics/; *see also* BANARES-SANCHEZ ET AL., *supra* note 12, at 5, 7-8 (describing increased emphasis on R&D across the Eleventh, Twelfth, and Thirteenth Five-Year Plans).

52. *But see* Inflation Reduction Act of 2022, Pub. L. No. 117-169, 136 Stat. 1818 (2022).

53. DAVID SANDALOW ET AL., THE OXFORD INST. FOR ENERGY STUDS., GUIDE TO CHINESE CLIMATE POLICY 2022 61 (2022). China is, moreover, not phasing out its PV feed-in tariff alone; an array of its clean-energy subsidies are "being withdrawn" now that China's world-leading producers no longer needs them. *See China's Clean-Energy Revolution Will Reshape Markets and Politics*, *supra* note 8.

54. Milton Ezrati, *The East-West Wage Gap Not Nearly As Compelling As It Once Was*, FORBES (Jan. 30, 2023, at 11:01 ET), https://www.forbes.com/sites/miltonezrati/2023/01/30/the-east-west-wage-gap-not-nearly-as-compelling-as-it-once-was.

55. TRIEU MAI ET AL., NAT'L RENEWABLE ENERGY LAB., IMPACTS OF FEDERAL TAX CREDIT EXTENSIONS ON RENEWABLE DEPLOYMENT AND POWER SECTOR EMISSIONS 1, 9-10 (2016).

China's PV industry has also vertically integrated from silicon mining to solar module production,[56] with China's (and the world's) four largest module manufacturers—Jinko Solar, Trina Solar, LONGi Green Energy Technology, and JA Solar —integrating cell and wafer supply chains.[57] Such integration has reduced Chinese PV leaders' exposure to supply chain disruptions and helped scale production.

Chinese manufacturers have also made their own advancements on technology across the solar value chain that have allowed China to make market-leading products. On metrics like cell conversion, Chinese solar producers have cut costs and increased sustainability via innovations such as composite/tandem cells, which layer different materials to convert more wavelengths on the electromagnetic spectrum into electricity.[58] So while China has historically produced copious but often low-quality research,[59] including in solar R&D,[60] China's PV titans today represent the technological cutting edge, securing their market dominance even as China's policy supports ebb.

III. GLOBAL BENEFITS AND COSTS OF CHINA'S SOLAR MANUFACTURING DOMINANCE

The world cannot afford to shun China as it undertakes the green transition. Experts estimate that across the energy transition as a whole, it would cost the world at least twenty percent more to transition without Chinese products.[61] China's solar industry is a central reason that the country's emissions are expected to decline years earlier than previously

56. Jessica Jin, *Solar PV Module Supply Chain Accelerates Consolidation in the Top 10 Suppliers*, S&P GLOB. (Feb. 14, 2024), https://spglobal.com/commodityinsights/en/ci/research-analysis/solar-pv-module-supply-chain-accelerates-consolidation.html.

57. *See id.*; Andrew Hayley, *China Solar Industry Faces Shakeout, but Rock-Bottom Prices to Persist*, REUTERS (Apr. 3, 2024, at 09:01 ET), https://www.reuters.com/business/energy/china-solar-industry-faces-shakeout-rock-bottom-prices-persist-2024-04-03.

58. Sangita Shetty, *Chinese Solar Pioneer LONGi Achieves Record-Breaking Efficiency in Tandem Solar Cells*, SOLARQUARTER (Nov. 4, 2023), https://www.solarquarter.com/2023/11/04/chinese-solar-pioneer-longi-achieves-record-breaking-efficiency-in-tandem-solar-cells.

59. Eleanor Olcott, et al., *China's Fake Science Industry: How 'Paper Mills' Threaten Progress*, FIN. TIMES (Mar. 28, 2023), https://www.ft.com/content/32440f74-7804-4637-a662-6cdc8f3fba86.

60. *See* Rongrong Li & Xuefeng Wang, *Imbalances Between the Quantity and Quality of China's Solar Energy Research*, MULTIDISCIPLINARY DIGIT. PUBL'G INST., Jan. 24, 2019, at 13, https://www.mdpi.com/2071-1050/11/3/623.

61. Rory McCarthy, *Not Made in China: The $6 Trillion Cost of Shifting the World's Cleantech Manufacturing Hub 5*, WOOD MACKENZIE (Feb. 12, 2024), https://www.woodmac.com/news/opinion/not-made-in-china-the-us$6-trillion-cost-of-shifting-the-worlds-clean-tech-manufacturing-hub/.

predicted[62]—and why global emissions may have peaked in 2023 and are projected to begin declining in coming years.[63] Such welcome news notwithstanding, the status quo remains unsustainable, with one of the pivotal industries of the green transition—and thus the future—located overwhelmingly within one autocratic country, posing security and resiliency risks to the global energy supply. Equity, meanwhile, is arguably both helped and hindered by various aspects of China's solar dominance. In view of such global dependence on China for the tools of decarbonization, Part IV will explore the costs and benefits of China's solar dominance for foreign countries and the green transition.

A. *China's Solar Growth Has Destroyed Western Countries' Domestic PV Producers*

China's booming PV manufacturing output has come at the price of eviscerating U.S. and EU solar producers over the past two decades. Over the course of the 2010s, employment in production and installation in Germany's solar industry fell by almost half,[64] with an estimated 70,000 solar manufacturing jobs moving from Germany to China over the past fifteen years.[65] Two decades ago, the United States made about twenty-two percent of the world's solar panels; today, it makes just one percent (roughly China's share in 2001).[66] The United States now has just one of the world's ten largest producers of solar modules, based on country of incorporation[67] (eight of the other nine

62. Sha Hua & Matthew Dalton, *China's Carbon Emissions Are Set to Decline Years Earlier Than Expected*, WALL ST. J. (Feb. 11, 2024, at 12:00 ET), https://www.wsj.com/world/china/chinas-carbon-emissions-are-set-to-decline-years-earlier-than-expected-cfc99dd2.

63. Simon Evans & Verner Viisainen, *Analysis: Global CO2 Emissions Could Peak as Soon as 2023, IEA data reveals*, CARBON BRIEF (Oct. 26, 2023, at 16:42 BST), https://www.carbonbrief.org/analysis-global-co2-emissions-could-peak-as-soon-as-2023-iea-data-reveals/.

64. enjamin Wehrmann, *Drop in Production and Installation Cuts Employment in German Renewables Sector*, CLEAN ENERGY WIRE (Feb. 4, 2021, at 13:12 CEST), https://www.cleanenergywire.org/news/correction-drop-production-and-installation-cuts-employment-german-renewables-sector.

65. Rob Schmitz, *China Dominates the Solar Power Industry. The EU Wants to Change That*, NAT'L PUB. RADIO (May 17, 2023, at 05:00 ET), https://www.npr.org/2023/05/17/1173250926/solar-power-eu-germany-china.

66. Jennifer A. Dlouhy, *How China Beat the U.S. to Become World's Undisputed Solar Champion*, BLOOMBERG (June 4, 2021, at 12:01 ET), https://www.bloomberg.com/news/articles/2021-06-04/solar-jobs-2021-how-china-beat-u-s-to-become-world-s-solar-champion.

67. K.Vaishnavi Srivalli, *Top 10 List of Solar PV Module Manufacturers in 2025*, BLACKRIDGE RSCH. & CONSULTING (Aug. 11, 2025, at 04:00 ET), https://www.blackridgeresearch.com/blog/top-solar-pv-module-panel-manufacturers-companies-suppliers-producers (First Solar is the sole U.S. solar module manufacturer on the list).

are Chinese).[68] And whereas China had 1.8 million jobs in PV manufacturing in 2022, the EU had 44,200, and the United States had just 34,000.[69] Although not grouped in precisely equivalent categories, non-manufacturing solar jobs are much more equal across major economies, with 918,000 construction, installation, and operation jobs in China; 367,000 solar deployment jobs in the EU; and 171,600 installation and project development jobs in the United States.[70]

In response to this solar deindustrialization, the EU and the United States have taken divergent paths. The EU removed its tariffs on Chinese solar in 2018 and has not reinstated them despite domestic industry pressure.[71] Perhaps as a result, almost half of China's solar exports in 2023 were to Europe.[72] By contrast, the United States, which in 2023 accounted for about sixty percent of the 289 countervailing duties (CVDs) in effect globally,[73] imposes numerous import duties against Chinese solar exports.[74] The U.S. strategy, however, is not necessarily better at protecting domestic jobs. Western leaders often focus on the consequences of lost manufacturing jobs, but given the greater share of workers in deployment occupations in the West, Western policymakers must consider how tariff-induced PV price spikes could harm that larger segment of jobs.[75] After all, falling solar prices yield growth

68. *Id.* Canadian Solar, though incorporated in Canada, has historically operated exclusively in China and should arguably be understood as a Chinese manufacturer despite shifting some of its production outside of China in response to U.S. tariffs on Chinese solar products. *See Registration No. 333-138144*, U.S. SEC. & EXCH. COMM'N (Oct. 23, 2006), https://www.sec.gov/Archives/edgar/data/1375877/000114554906001563/h00554a3fv1za.htm; Zeyi Yang, *This Solar Giant is Moving Manufacturing Back to the US*, MIT TECH. REV. (Apr. 23, 2024), https://www.technologyreview.com/2024/04/23/1091665/canadian-solar-ira-manufacturing-us/.

69. INT'L RENEWABLE ENERGY AGENCY, RENEWABLE ENERGY AND JOBS ANNUAL REVIEW 2023 40, 44, 49 (2023).

70. *Id.*

71. Hancock, *supra* note 15.

72. Hayley, *supra* note 57.

73. JENNIFER A. HILLMAN & INU MANAK, COUNCIL ON FOREIGN RELATIONS, RETHINKING INTERNATIONAL RULES ON SUBSIDIES 8-16 (2023), https://www.cfr.org/report/rethinking-international-rules-subsidies.

74. Nichola Groom, *US Places Tariffs on Some Big Solar Companies for Dodging China Duties*, REUTERS (Aug. 18, 2023, at 11:49 ET), https://www.reuters.com/sustainability/us-slaps-tariffs-some-big-solar-companies-dodging-china-duties-2023-08-18/.

75. *See* Eric Wesoff & Maria Virginia Olano, *Chart: Most US Solar Jobs Are in Installation, Not Manufacturing*, CANARY MEDIA (June 3, 2022), https://www.canarymedia.com/articles/solar/chart-most-us-solar-jobs-are-in-installation-not-manufacturing.

in solar non-manufacturing jobs[76] and correlate with rising PV installation rates, in the United States as elsewhere.[77]

B. *China's High Production Capacity Benefits Global Solar Deployment, Especially in LDCs, But Supply Chain Concentration Could Impede an Equitable Transition*

For the rest of the world, China's soaring solar production capacity is both a blessing and a curse. Explosive output growth caused solar module spot prices, already around record lows, to fall by half in 2023,[78] but while low prices benefit the pace of global decarbonization, experts have raised concerns that solar overproduction threatens the stability of the PV market.[79] China's production capacity for solar wafers, cells, and modules (roughly 850 gigawatts' (GW) worth of each), for instance, is more than double the amount of solar installed globally in 2023 (just 390 GW).[80] A further 500-600 GW of PV production capacity was expected to come online in 2024.[81] Amid such punishing competition for market share, China's four largest solar producers' share prices fell by more than half from January 2022 to March 2024,[82] spurring huge layoffs last year.[83] Ultrathin margins have raised fears of company failures and led Chinese solar executives to predict many producers will soon go out of business.[84]

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76. *See* Hannah Ritchie, *Do Imports of Cheap Solar Panel and Other Technologies Help or Hurt Domestic Jobs in Clean Energy?*, SUSTAINABILITY BY NOS. (Apr. 21, 2025), https://www.sustainabilitybynumbers.com/p/clean-energy-imports-jobs.

77. *See Solar Indus. Rsch. Data*, SOLAR ENERGY INDUS. ASSOC., https://www.seia.org/solar-industry-research-data (last visited Oct. 5, 2025) (citing SOLAR ENERGY INDUS. ASSOC. & WOOD MACKENZIE, SOLAR MKT. INSIGHT REP. Q3 2025 (2025)).

78. Alex Blackburne, *World Stuck in Major Solar Panel 'Supply Glut'; Module Prices Plummet: IEA*, S&P GLOB. (Jan. 12, 2024, at 22:21 UTC) (citing INT'L ENERGY AGENCY [IEA], RENEWABLES 2023 9 (2024), https://www.iea.org/reports/renewables-2023), https://www.spglobal.com/commodity-insights/en/news-research/latest-news/electric-power/011224-world-stuck-in-major-solar-panel-supply-glut-module-prices-plummet-iea.

79. *See, e.g.*, Ali Imran Naqvi, *Solar Industry Faces Collapse Amid Surplus and Plunging Prices*, PV MAGAZINE (Aug. 28, 2024), https://www.pv-magazine-india.com/2024/08/28/solar-industry-faces-collapse-amid-surplus-and-plunging-prices/.

80. Hayley, *supra* note 57.

81. *Id.*

82. *Id.*

83. *See Top Solar Firm Longi Plans Thousands of Job Cuts on Glut*, BLOOMBERG (Mar. 18, 2024, at 04:20 ET), https://www.bloomberg.com/news/articles/2024-03-18/world-s-top-solar-firm-longi-plans-thousands-of-job-cuts-on-glut.

84. *See Top Solar Firm Warns Excess Capacity Risks Wave of Failures*, BLOOMBERG (May 24, 2023, at 5:27 ET), https://www.bloomberg.com/news/articles/2023-05-24/top-solar-firm-warns-excess-capacity-may-bring-wave-of-failures; David Stringer, *China's Smaller Solar Firms at Risk in Industry Shakeout*, BLOOMBERG (Mar. 25, 2024, at 07:42 ET), https://www.bloomberg.com/news/newsletters/2024-03-25/china-s-smaller-solar-firms-at-risk-in-industry-shakeout.

Solar buyers, however, have benefited from price wars and booming production. Least developed countries (LDCs) and developing countries, for instance, are particularly sensitive to the reliability and price of energy, making China's high volume and steady supply of affordable solar panels essential to decarbonization in much of the world—including in China itself. In 2023, solar made up more than fifteen percent of annual electricity generation in countries such as Yemen (16.9%), El Salvador (19.1%), and Namibia (27%).[85] China's PV share of electricity in 2023 was only 6.18%, but by 2024, China's world-leading solar production of 839 terawatt (TWh) hours exceeded second-place U.S.'s solar generation by more than 500 TWh.[86] The exceptionally low cost of solar is a key reason that solar now drives China's decarbonization strategy, with its announced pledges totaling 200 GW of PV installed annually from 2020 to 2060.[87] Low cost is also why developing countries like El Salvador and Namibia can rely on solar for so much of their power.

Still, the green transition will provide the greatest benefits to the countries whose economies contribute most significantly to the technical innovations and infrastructure deployment it will require. Countries without green transition industries will thus enjoy fewer of their fruits and will acquire less of the technical expertise required to implement green technologies (e.g. adding solar to the existing power grid in LDCs). So, while Chinese dominance could entail cheaper products in developing countries (assuming overcapacity proves harmless), it could also undermine the equity of the transition.

C. *China's Solar Supply Chain Relies on Coal Power, Raising Emissions Intensity, and Involves Human Rights Violations Such as Forced Labor of Uyghurs in Xinjiang*

China's solar miracle does, however, have a dark side, chiefly the forced labor in its supply chain and China's reliance on coal to power its factories. First, Uyghurs, a Muslim ethnic minority who live in the Xinjiang Uyghur Autonomous Region, have for years been forced to

85. *Electricity Data Explorer*, EMBER, https://ember-climate.org/data/data-tools/data-explorer/ (enter the country name into the "Search" box and select "% Share" as the metric; then select "2023" as the year); *see* UNITED NATIONS CONFERENCE ON TRADE & DEV., COUNTRIES, ALL GROUPS HIERARCHY, UNCTADSTAT (Apr. 14, 2025), https://unctadstat.unctad.org/EN/Classifications/DimCountries_All_Hierarchy.pdf (identifying El Salvador, Namibia, and Yemen as "developing economies").

86. *Id.*

87. *An Energy Sector Roadmap to Carbon Neutrality in China: Executive Summary*, INT'L ENERGY AGENCY (2021), https://www.iea.org/reports/an-energy-sector-roadmap-to-carbon-neutrality-in-china/executive-summary.

work in the province's factories, including solar facilities.[88] To address ongoing human rights violations in Xinjiang, the United States passed the Uyghur Forced Labor Prevention Act (UFLPA), which took effect in 2022[89] and established a "rebuttable presumption that goods mined, produced, or manufactured wholly or in part in [Xinjiang]" were "prohibited from U.S. importation under 19 U.S.C. § 1307," which bans products made with forced labor.[90] Chinese products verifiably made without Uyghur forced labor are, however, not subject to import restrictions in the United States under the UFLPA, and with Chinese polysilicon not from Xinjiang now entering the United States,[91] the UFLPA appears to have successfully kept tainted goods out of the United States without completely locking out Chinese products.[92] This suggests the UFLPA has not shut down China's polysilicon production but has instead shifted some to regions without Uyghur forced labor. Though U.S. Customs and Border Protection's early implementation of the UFLPA was unpredictable, the law has become more consistent as more guidance has designated applicable entities and covered industries.[93] Still, global policymakers should find further measures for discouraging violations of human rights without impeding the green transition.

Second, China's PV production in Xinjiang and other key provinces has been made cheap partly by powering factories with coal,[94] which still generated most of China's power in 2024.[95] Such heavy use of coal-

88. Stuart Lau & Antonia Zimmermann, *Forced Labor Still Haunts China's Xinjiang, Report Finds*, POLITICO (Feb. 13, 2024, at 06:00 CET), https://www.politico.eu/article/forced-labor-still-haunts-chinese-region-of-xinjiang-report-finds.

89. Pub. L. No. 117-78, 135 Stat. 1530 (2021).

90. *Uyghur Forced Labor Prevention Act*, U.S. CUSTOMS & BORDER PROT., https://www.cbp.gov/trade/forced-labor/UFLPA (last visited May 14, 2024).

91. *See* Sylvia Leyva Martinez & Elissa Pierce, *Turn of the Tide? What the Entry of Chinese Polysilicon to the US Means for the American Solar Supply Chain*, WOOD MACKENZIE (Nov. 18, 2023), https://www.woodmac.com/news/opinion/turn-of-the-tide-what-the-entry-of-chinese-polysilicon-to-the-us-means-for-the-american-solar-supply-chain/.

92. *Id.*

93. *See, e.g.*, *International Trade 2024 Year-End Update*, GIBSON DUNN (Feb. 6, 2025), https://www.gibsondunn.com/international-trade-2024-year-end-update/.

94. *Rise of China's Xinjiang as Coal Hub Undercuts Climate Goals*, BLOOMBERG (Nov. 27, 2024, at 15:52 ET), https://www.bloomberg.com/news/articles/2024-11-27/rise-of-china-s-xinjiang-as-coal-hub-undercuts-climate-goals.

95. *See China*, EMBER, https://ember-energy.org/countries-and-regions/china/(last visited Apr. 22, 2025); *see also* Gavin Maguire, *China's Cut to Coal Power Share Is a Rare but Key Climate Win*, REUTERS (Nov. 27, 2024, at 11:48 ET), https://www.reuters.com/business/energy/chinas-cut-coal-power-share-is-rare-key-climate-win-maguire-2024-11-27/(noting that China generates a shrinking majority of its power from coal).

fired power means that Chinese solar panels currently have needlessly high embodied emissions, and even with China accelerating its deployment of solar, such emissions are unlikely to change quickly, given that almost none of China's new PV capacity is in Xinjiang.[96] Instead, much of China's new solar has been installed in its eastern provinces, thousands of miles from Xinjiang (China's northwesternmost province), with the large solar farms closest to Xinjiang still hundreds of miles away in Inner Mongolia's Kubuqi Desert.[97] Worse still, much of the solar China builds goes significantly underutilized, generating limited power even relative to solar's typically low capacity factors.[98] For the foreseeable future, therefore, China is likely to make solar with coal, scaling up or retaining fossil fuel infrastructure to build the clean energy products of the future and preventing solar panels from achieving their lowest potential emissions intensity in the meantime.

IV. WHY AND HOW THE GROUP OF 20 SHOULD IMPLEMENT A GREEN PACT

For U.S. and global interests, China's contribution to solar production confers many benefits, but China's unchecked dominance of solar manufacturing poses an intolerable security risk that may impede equitable decarbonization. In response to China, the world should permit—indeed, welcome—solar subsidies but should insist on policies that make the solar supply chain cleaner, more consistent with human rights, and more evenly distributed around the world. If China is to depart from WTO rules on subsidies to achieve much-needed growth in green sectors, the rest of the world should be allowed to do so, too.[99]

In some ways, such a system prevails already: Experts note that subsidies can be cumbersome to identify and even harder to challenge,[100] and the WTO Appellate Body sits vacant,[101] likely for the foreseeable future, paralyzing WTO dispute resolution. Against this backdrop, most countries' options are limited. Few can afford to impose tariffs, let alone on

96. Joseph Webster, *There's Something Odd About Where China Is Building Solar Power*, ATL. COUNCIL: NEW ATLANTICIST (July 27, 2023), https://www.atlanticcouncil.org/blogs/new-atlanticist/theres-something-odd-about-where-china-is-building-solar-power/.

97. *China's Remote Deserts Are Hiding an Energy Revolution*, BLOOMBERG (Nov. 26, 2023), https://www.bloomberg.com/graphics/2023-china-solar-wind-power-cop28/.

98. *See* Webster, *supra* note 96.

99. Dani Rodrik, *Don't Fret About Green Subsidies*, PROJECT SYNDICATE (May 10, 2024), https://www.project-syndicate.org/commentary/green-subsidies-justified-on-economic-environmental-and-moral-grounds-by-dani-rodrik-2024-05.

100. HILLMAN & MANAK, *supra* note 73, at 10, 12-13.

101. *Appellate Body*, WORLD TRADE ORG., https://www.wto.org/english/tratop_e/dispu_e/appellate_body_e.htm (last visited Apr. 22, 2025).

their largest trading partners. Only large economies like China, the United States, and the EU can usually afford to retaliate against each other's preferential treatment of domestic industry. Moreover, the developing countries and LDCs most vulnerable to climate change are also least likely to attempt to compete with China, even if they opted for the most generous subsidies possible. They thus stand to lose most from major economies' tariff battles, which do nothing to spur the growth of solar production or lower prices in the countries that most urgently need to adapt.

Taking lessons from China's dominance of the solar industry, this Part will therefore argue that the G20 should dispense with trade barriers on green goods and instead pursue a WTO "Green Pact," wherein all parties agree not to challenge each other's green subsidies and instead focus on supporting their domestic green manufacturing. To maximize innovation and motivate economies such as China and India to participate, a Green Pact should particularly work to eliminate tariffs on outdated PV technology and encourage subsidies for R&D.[102] This Part will make the case for a Green Pact, describe its ideal participants, argue for one definition of "green," identify which subsidies a Green Pact would permit, and make recommendations for its implementation.[103]

A. *A G20 Green Pact Would Help the World Address the Climate Crisis*

Current WTO law has not allowed countries adequate policy latitude to pursue the green transition at the necessary pace. Few assessments of the world's pace of decarbonization believe humanity is on track to meet its climate targets.[104] The failure of markets to develop and deploy

102. For years, analysts have anticipated India may become the world's second-largest manufacturer of solar PV, perhaps as soon as 2026, with module production capacity of 110 GW. *See India Could Become the World's Second-largest Solar Photovoltaic Manufacturer by 2026*, INST. FOR ENERGY ECON. & FIN. ANALYSIS (Apr. 4, 2023), https://ieefa.org/articles/india-could-become-worlds-second-largest-solar-photovoltaic-manufacturer-2026. As its production capacity has grown, moreover, India has taken steps to decrease its protectionism: In 2024, for instance, India sought to boost solar adoption and production by lifting a 7.5% basic customs duty on certain equipment used in solar manufacturing. Uma Gupta, *Budget 2024-25: India Imposes Customs Duty on Solar Glass Imports, Exempts Equipment For Cell and Module Manufacturing*, PV MAGAZINE (July 23, 2024), https://www.pv-magazine-india.com/2024/07/23/budget-2024-25-india-introduces-duty-on-solar-glass-imports-exempts-equipment-for-solar-cell-and-module-production/. Indeed, India's potential to become a PV exporter could make a Green Pact more appealing. *See supra* INST. FOR ENERGY ECON. & FIN. ANALYSIS. This would be particularly true if the Pact eliminated tariffs on older PV technology.

103. Given forced labor of Uyghurs in Xinjiang, nothing in this Pact should affect existing international law on human rights violations and measures countries may take in response.

104. *See, e.g.*, *How Are We Tracking?*, SPEED & SCALE, https://speedandscale.com/tracker/ (last visited Apr. 26, 2024); *see also Renewable Energy Progress Tracker*, INT'L ENERGY AGENCY (Jan. 11, 2024), https://www.iea.org/data-and-statistics/data-tools/renewable-energy-progress-tracker.

new green technologies presents a clear case for the intervention of governments to accelerate innovation and subsidize the production of green goods—irrespective of their competitiveness. As experts have noted, however, "current limits on subsidies in the [Agreement on Subsidies and Countervailing Measures] do not take into account any policy justification for a subsidy."[105] As such, the G20—whose members account for most installation and almost all production of solar PV globally[106]—should make a Green Pact to allow its members to fight the climate crisis with far greater fiscal firepower.

Historically, classical economic theory opposes subsidies for their inefficiency, arguing they distort markets by warping price signals and allowing governments to pick winners and losers.[107] Today, however, governments are intervening in already-distorted markets to prioritize "green security" goals: energy security, supply chain resiliency, and decarbonization.[108] These are legitimate objectives of any country's economic policies, and though these goals may sometimes clash with economic efficiency, some governments now appear to believe that green security goals necessitate major green investments, optimally efficient or not.[109]

Still, runaway government intervention remains a meaningful risk of a Green Pact. With finite demand for solar products, heavy subsidization of solar manufacturing could cause the present glut of supply to persist—which, as noted in Part II—China's solar industry leaders have feared for years.[110] European and American solar manufacturers allege that China's glut of production and plunging prices amount to dumping, threatening to bankrupt non-Chinese solar producers.[111] Western subsidies, however, could ignite domestic manufacturing renaissances of their own.[112]

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105. STEVE CHARNOVITZ, GREEN SUBSIDIES AND THE WTO 17 (2014).

106. *See Country Rankings*, INT'L RENEWABLE ENERGY AGENCY, https://www.irena.org/Data/View-data-by-topic/Capacity-and-Generation/Country-Rankings (last visited Nov. 11, 2025); INT'L ENERGY AGENCY, RENEWABLES 2023 25-26 (2024), https://www.iea.org/reports/renewables-2023; *G20 Members*, G20 S. AF. 2025, https://g20.org/about-g20/g20-members/ (last visited Nov. 11, 2025).

107. *See generally* JOSE GUILHERME MORENO CAIADO, COMMITMENTS AND FLEXIBILITIES IN THE WTO AGREEMENT ON SUBSIDIES AND COUNTERVAILING MEASURES 61-98 (2019).

108. *See* Inflation Reduction Act of 2022, Pub. L. No. 117-169, 136 Stat. 1818.

109. *See, e.g.*, Dimitri Zabelin & Daan-Max von Dongen, *How Geopolitics Will Both Hinder and Accelerate the Global Energy Transition*, WORLD ECON. F. (Oct. 28, 2024), https://www.weforum.org/stories/2024/10/geopolitics-energy-transition/.

110. Sha Hua & Phred Dvorak, *China's Spending on Green Energy Is Causing a Global Glut*, WALL ST. J. (Nov. 13, 2023, at 13:12 ET), https://www.wsj.com/business/chinas-spending-on-green-energy-is-causing-a-global-glut-d80eaea7.

111. *See* Hancock, *supra* note 15.

112. Dvorak & Mollica, *supra* note 6.

Following the passage of the Inflation Reduction Act in 2022, First Solar announced it would invest up to $1.2 billion to expand its U.S. production.[113] If incentives for domestic solar production (and not just installation) grew more generous, more companies would likely follow. But while fiscal support would help catalyze durable green industry, so, too, would fairness—another reason for a Green Pact. Countries' efforts to finance climate mitigation should be cheered, not challenged, but all countries must be equally free to support domestic green champions, subject only to common-sense limits laid out in Part IV(C).

Perhaps the best reason for a Green Pact, though, is neither security nor fairness but the lack of alternatives. First, with a vacant WTO Appellate Body unable to hear challenges, a Green Pact amounts to realpolitik on subsidies. Acknowledging that subsidies may be hard to dispute for the foreseeable future, a Green Pact would choose the more desirable climate policy outcome of increasing total global subsidies instead of making green goods more expensive via CVDs. Second, if countries are barred from subsidizing green technologies and green production, the world will be at the mercy of the private sector, which has yet to single-handedly solve any aspect of the climate crisis. Ironically, despite the central role of government in its rise, China's solar industry has lately been called a "part of the economy where the private sector is dominant, and where the prospects for reducing global emissions are good."[114] But if China's solar success suggests that state support need not be permanent, it also suggests governments must lead at the start, providing guaranteed demand and/or financing before technologies enter the mainstream.[115]

A Green Pact will have the greatest, most equitable impact if undertaken by the Group of 20. Together, the G20 accounts for about eighty-four percent of global electricity demand[116] and for the vast majority of global emissions, both today and historically.[117] Such coverage of energy

113. Ivan Penn, *First Solar Says It Will Spend up to $1.2 Billion to Expand U.S. Production*, N.Y. TIMES (Aug. 30, 2022), https://www.nytimes.com/2022/08/30/business/energy-environment/first-solar-says-it-will-spend-up-to-1-2-billion-to-expand-us-production.html.

114. David Fickling, *Yellen Junks 200 Years of Economics to Block China Clean Tech*, BLOOMBERG (Apr. 8, 2024, at 5:00 PM), https://www.bloomberg.com/opinion/articles/2024-04-08/yellen-junks-200-years-of-economics-to-block-china-clean-tech.

115. *See generally* EVERETT M. ROGERS, DIFFUSION OF INNOVATIONS (5th ed. 2003) (describing how technologies become cheaper and less reliant on state support as they mature and scale).

116. *G20*, EMBER, https://ember-climate.org/countries-and-regions/regions/g20/ (last visited May 6, 2024).

117. *See CO_2 Emissions*, OUR WORLD IN DATA, https://ourworldindata.org/co2-emissions (last visited Apr. 26, 2024).

demand and emissions would be vital to the success of a Green Pact, asking more of countries who are historically accountable for the climate crisis while also creating incentives for pivotal economies like China and India whose future emissions will primarily determine whether the world stays below two degrees Celsius of warming, the Paris Agreement's intended upper limit.[118] Indeed, a Green Pact should be structured to entice China and India (leading producers of older PV designs with lower conversion efficiency[119]) to join the Pact by prohibiting tariffs on green energy goods that are no longer cutting-edge while allowing China's and India's outdated green technology into their markets under a Green Pact. The United States and EU should focus their subsidies instead on R&D in batteries and electric vehicles—industries where the West could nurture competitive producers in coming decades. Applying a Green Pact to all G20 economies would thus benefit all participants,[120] allowing China to pursue its effective subsidy regime subject to key guardrails while allowing the West to join in such policies.[121]

A Green Pact would also help realize the G20's green transition goals. In 2023, the G20 met in New Delhi and committed to "pursue and encourage efforts to triple renewable energy capacity globally" by 2030 and to "advance cooperation initiatives to develop, demonstrate and deploy clean and sustainable energy technologies."[122] G20 leaders also called "on Parties [to the Paris Agreement] to set an ambitious, transparent and trackable New Collective Quantified Goal (NCQG) of climate finance in 2024, from a floor of USD 100 billion a year, taking into account the needs and priorities of developing countries."[123] Consistent with these goals, the G20 recognized that "it is essential to align all relevant financial flows with these objectives while scaling up finance, capacity building and technology transfer."[124] By expanding the legitimate options for subsidizing clean energy, a Green Pact would

118. Paris Agreement to the United Nations Framework Convention on Climate Change, art. 2, Dec. 12, 2015, T.I.A.S. No. 16-1104.

119. India in particular primarily produces older solar technologies such as polycrystalline and monocrystalline panels. *See* Kshiteej Mishra, *The Evolving Landscape of Solar Manufacturing*, PV MAGAZINE (Jan. 2, 2025), https://www.pv-magazine-india.com/2025/01/02/the-evolving-landscape-of-solar-manufacturing/.

120. *See* Rodrik, *supra* note 99.

121. Applying a Green Pact to the G20 would also include all the countries practically able to pursue green subsidies without covering the many LDCs and developing countries whose participation would be unlikely to matter.

122. *G20 New Delhi Leaders' Declaration*, INDIAN MINISTRY EXTERNAL AFFS. (Sep. 10, 2023), https://www.mea.gov.in/Images/CPV/G20-New-Delhi-Leaders-Declaration.pdf.

123. *Id.*

124. *Id.*

thus align with the G20's stated goals and help implement its most ambitious goals.[125]

B. *A Green Pact Should Allow Two Categories of "Green Subsidies" While Establishing a Green Subsidy Registry and Verification System*

A Green Pact should create two categories of permitted "green subsidies" that must be claimed in a WTO registry and described in some detail to qualify for Green Pact treatment: *per se* green products and low-embodied-emissions products. While participating countries could adopt different precise thresholds or approve products different from those proposed below, these categories would provide clear guidelines subject to the limits noted in Part IV(C).

First, *per se* (or preapproved) green products would qualify as "green" by decarbonizing a given end use, either because they directly displace fossil fuels or because they are an input of a final product which does so. Products in this category could include renewable energy products such as solar wafers, wind turbine blades, or batteries, and material inputs like silicon and lithium. Products upstream in the supply chain would, of course, less clearly qualify as *per se* green. In the wind industry, for instance, an initial steel manufacturer may not know whether their product will later become part of a hypothetical wind turbine; in the solar context, only twelve percent of metallurgical-grade silicon is used in PV panels.[126]

To address such ambiguities, Pact member countries could begin with clearly eligible producers (e.g. solar panel manufacturers) and work backwards by requiring—as a condition of eligibility for subsidies—that producers list their suppliers of inputs or raw materials. Upstream suppliers' eligibility would thus be based in turn on being claimed by a downstream producer, creating a clear connection of inputs to final products. Upstream producers' subsidies would then be in proportion to the share of their products that went to approved green buyers.

Per se green products should, however, be limited to those that are themselves green or directly supply such products.[127] Such a limitation

125. Subsidizing clean energy technology would, for instance, align with the G20's goal of tripling renewables by 2030.

126. U.S. DEPT. ENERGY, SOLAR PHOTOVOLTAICS SUPPLY CHAIN DEEP DIVE ASSESSMENT iii (2022), https://www.energy.gov/sites/default/files/2022-02/Solar%20Energy%20Supply%20Chain%20Report%20-%20Final.pdf.

127. Here, an iron producer that supplied a steelmaker whose steel was used in wind turbines would not qualify as *per se* green, but both the turbine producer and its direct steel supplier would. Or if a battery producer were designated as *per se* green, then its lithium supplier would be directly supplying an approved green buyer (the battery maker) and would be eligible for subsidies.

avoids attenuated connections to the actual green product. Though this documentation process would take time and administrative resources, this burden would fall on subsidized producers in G20 countries and would be essential to the WTO subsidy registration process described below.

Additionally, to simplify the determination of which downstream producers qualify as "green" in the first place, Green Pact countries should establish a collectively preapproved list of *per se* green products and criteria for inclusion of more as technology advances. This category should be fully non-actionable and should thus err on the side of being more restrictive. The list of *per se* green products should, however, be revisited annually, with only additions to the list allowed until 2050 and then either addition or subtraction of products permissible thereafter.[128]

This first category is necessary because some products—such as China's solar panel inputs made using coal-fired power—will have substantial embodied emissions but will be needed to transition the power sector itself off fossil fuels. To exclude such products for their substantial embodied emissions would make the perfect the enemy of the good and leave out the majority of the technologies needed to decarbonize global power generation.

Second, a Green Pact should permit subsidies for energy-intensive, trade-exposed (EITE) products that do not displace fossil fuels but which have low embodied emissions. These low-emissions EITE (LEITE) products would include commonly accepted EITE products such as aluminum, ammonia, cement, chemicals, electricity, fertilizer, glass, iron, and steel and would apply to goods with embedded emissions less than the subsidizing country's domestic industry average.[129] While Pact countries could determine exact eligibility thresholds (e.g. subsidies for goods with fifty percent lower embedded emissions than the relevant average), some standard for the reduction in embodied emissions would be necessary to ensure that countries are not simply subsidizing industry-average products under the guise of climate action.

To administer LEITE subsidy programs, Pact countries could each either (1) assess their domestic industry and products to be subsidized and then publish their data to obtain other Pact countries' approval or (2) accept an IMF/World Bank estimate of their domestic industry average. The first subsidy-verification path could require the use of

128. Such an extended introductory period would maintain products' eligibility to give technologies time to mature.

129. BRIAN FLANNERY ET AL., POLICY GUIDANCE FOR US GHG TAX LEGISLATION AND REGULATION 13-14 (2020), https://media.rff.org/documents/Policy_Guidance_Upate.pdf.

environmental product declarations (EPDs) based on life cycle assessments of a goods' embedded emissions. Upon receiving an EPD for a LEITE product the providing country had begun to subsidize, other Pact countries could have a period (e.g. two years) to review and approve the submitted data to ensure compliance with Pact members' chosen emissions-reduction threshold, and some share of Pact participants (perhaps twenty-five percent) could suffice to reject countries' own estimates and require use of an IMF/World Bank default estimate instead. Countries' claimed LEITE subsidies could be rejected by a majority of other Pact members if it could be shown that a subsidized product's emissions materially departed from the agreed threshold for reduced emissions intensity.

For both of the two foregoing categories of subsidies, the subsidizing country should be required to declare the following when registering their subsidy with the WTO: (1) the estimated amount of the subsidy provided or, if the subsidy is uncapped but subject to certain eligibility criteria, annual updates to the estimated cumulative subsidy uptake; (2) the specific industries and individual producers receiving the subsidy, or those that the subsidizing country expects will receive or be eligible for it; (3) the planned duration of the subsidy, unless one-time; and (4) the estimated greenhouse gas (GHG) reductions expected from varying degrees of subsidy uptake (e.g. if fifty percent of authorized funds are deployed, Country X expects a reduction of one gigaton of CO_2e relative to an equivalent output over five years). To ease the administrative burden, Pact members could petition other participants for a waiver of the GHG-reduction estimation requirement, with majority support sufficient to waive the obligation.

Together, these two categories of green subsidy—for fossil fuel-displacing goods and for low-emissions, energy-intensive, trade-impacted goods—would accelerate decarbonization of the power and industrial sectors and reduce the emissions intensity of new infrastructure. The registration and disclosure process for these subsidies would create transparency, allow for assessment of the subsidies' efficacy and possible inclusion in countries' Paris Agreement nationally determined contributions, and level the playing field for G20 countries pursuing green subsidies. Such a structure would establish a clear, accountable, and relatively efficient G20 green subsidy regime as the Group pursues its current climate goals and grows its ambitions in coming years.

C. *A Green Pact Should Establish Criteria for Green Subsidies to Be Non-Actionable*

A Green Pact is premised on permitting countries to respond to each other's subsidies with subsidies of their own without allowing them to challenge those foreign subsidies. After all, as observed in Part III,

cheap solar products redound to the benefit of all buyers. Such a regime accords with UNFCCC Article 3.5, which provides that measures to "combat climate change, including unilateral ones, should not constitute a means of arbitrary or unjustifiable discrimination or a disguised restriction on international trade."[130] G20 members should carry the provisions of Article 3.5 into the Green Pact and designate green subsidies that meet certain criteria as non-actionable.

Fortunately, precedent exists for green subsidies to receive such special treatment, most notably in Article 8 of the Agreement on Subsidies and Countervailing Measures (SCM). Though now lapsed,[131] SCM Article 8 provided that subsidies for environmental upgrades to existing facilities were non-actionable.[132] In that spirit, though on a far larger scale, Green Pact countries could treat green subsidies as non-actionable unless they enabled dumping or made up the majority of a producer's revenue, at which point the subsidy would become actionable.[133]

These conditions on green subsidies have both climate and economic rationales. First, dumping in foreign markets, while arguably a benefit from the producing country to consumers in the importing country, undercuts the viability of green manufacturing in the consuming country. Dumping thus creates a more zero-sum structure to green industries—the precise outcome the Green Pact seeks to avoid—and does nothing to advance total global solar production. And as noted in Part III, as long as China dominates the solar supply chain, other countries will be vulnerable to political, economic, and public health disruptions in China. While Chinese subsidies benefit foreign importers and need not undermine foreign producers' viability, dumping of subsidized solar products unfairly hampers the potential to diversify PV production.

Second, subsidies that amount to most of a producer's income (including via avoided costs) are likely neither enabling deployment of promising new technologies nor increasing profits in semi-mature markets with high demand. Such subsidies are, instead, presumably the only reason a green product is viable. In most areas of the green transition, however, multiple candidate technologies exist for each use case, so by subsidizing even uncompetitive products, governments would be propping up some rightful losers, delaying the dominance and

130. United Nations Framework Convention on Climate Change, art. 3.5, Mar. 21, 1994, 1771 U.N.T.S. 107.

131. WORLD TRADE ORG., WORLD TRADE REPORT 2006 192 (2006).

132. Agreement on Subsidies and Countervailing Measures, art 8.2, Apr. 15, 1994, Marrakesh Agreement Establishing the World Trade Organization, Annex 1A, 1869 U.N.T.S. 14.

133. Article 8 of the SCM Agreement limited non-actionable subsidies to "75% of the costs of industrial research or 50% of the costs of pre-competitive development activity." *See id.*

accelerated deployment of more cost-effective options by masking price signals. Capping subsidies at half of producers' revenues would thus help mitigate the risk of inefficient market interventions.

The Green Pact should also depart from the lapsed Article 8 rules by permitting non-actionable subsidies to persist indefinitely as long as they meet the two aforementioned criteria. Today, solar capacity is among the only areas of the energy transition and climate technology generally that is estimated to be on track to meet global 2030 and 2050 decarbonization goals.[134] But even if solar deployment is occurring at the necessary rate, its distribution across the globe suffers from the issues identified in Part III, and the world is not deploying non-solar clean energy technologies at anywhere near the rate required.[135] Although solar subsidies might be a candidate for phase-outs in the 2030s or 2040s, a Green Pact therefore should not impose time constraints on green subsidies, for such limits could destabilize or discourage investment in off-track sectors.

The proposed Green Pact rules making qualified green subsidies non-actionable should use the definition of "subsidies" laid out in SCM Articles 1 and 2.[136] Protecting all the tools states have to confer benefits is critical, as many of the key instruments for promoting green manufacturing will not be direct income or price supports from governments but instead will be financing, such as low-interest loans from "green banks" and other public bodies created to stand up green industry. Making all such tools non-actionable could encourage more market-oriented subsidies and choose potentially less trade-distorting means of promoting green industry.

V. Conclusion

In a moment of resurgent protectionism, major economies risk raising the costs of green goods by imposing tariffs on foreign products rather than pursuing domestic green subsidies to make such goods cheaper and more abundant. Inspired by the success of China's solar industry, a Green Pact among the G20 countries to allow subsidization of green products would instead grow green industries globally, spurring sustainable growth and accelerating a just transition.

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134. *Tripling Global Renewables By 2030 Is Hard, Achievable and Necessary to Achieve Net Zero*, Bloomberg (Nov. 21, 2023), https://about.bnef.com/blog/tripling-global-renewables-by-2030-is-hard-achievable-and-necessary-to-achieve-net-zero/.

135. *See id.*

136. SCM Articles 1 and 2 deem subsidies to include, among other things, beneficial price supports and financial contributions by governments or public bodies. *See* Agreement on Subsidies and Countervailing Measures, *supra* note 132, arts. 1-2.