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SOUTH KOREA'S SOLAR POWER INDUSTRY:

STATUS AND PROSPECTS

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By Jae Ho Yun and Chinho Park
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Introduction

China's growing global market dominance in solar photovoltaic (PV) supply chains has created considerable challenges for South Korea's PV industry in various value chain sectors. Notwithstanding high levels of technological expertise, the polysilicon and wafer sectors in South Korea's domestic PV industry have collapsed. Some hope that expanding South Korea's solar PV market will help secure global competitiveness for domestic cell and module manufacturers, but whether expansion will have this result remains to be seen. Indeed, the combination of attractive manufacturing incentives in the US Inflation Reduction Act and a decline in solar PV installation within South Korea has encouraged some of the country's leading firms to expand manufacturing overseas. This has in turn prompted concerns about hollowing out of South Korea's domestic manufacturing capacity. Recognizing that both US policy and US markets are creating a strong pull for South Korean companies, we believe that revitalizing the country's domestic PV supply chains will require a new strategy—one that avoids enhancing America's supply chains at the expense of South Korea's and is instead based in friend-shoring and cooperation.

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South Korea's Domestic PV Market

South Korea's domestic solar PV market is among the top 10 in the world. In 2022, South Korea had the ninth-largest cumulative installed capacity, at 24.8 GW.[1] Nevertheless, the country's capacity additions slowed somewhat in 2022, from 4.1 GW in 2020 and 4.2 GW in 2021 to an estimated 3.6 GW in 2022.[2] The PV penetration rate—solar PV's theoretical share in national electricity demand—increased slightly, from 4.6% in 2021 to 4.7% in 2022.[3] This was not sufficient to place South Korea within the world's top-25 countries; PV penetration in the European Union (EU) was 8.7% due to high rates in Spain (19.1%), Greece (17.5%), the Netherlands (15.9%), and Germany (12.4%).[4] Table 1 displays the world's top-10 counties by new capacity and cumulative capacity installed in 2022.

South Korea's government regularly sets its plans for the electric power sector through the Basic Plan for Long-Term Electricity Supply and Demand. In January 2023, the Yoon Suk Yeol administration released the 10th Basic Plan.[5] Under the plan, renewable electricity generation should account for 21.6% of total power generation by 2030 and 30.6% by 2036, reflecting a

1 International Energy Agency, "Snapshot of Global PV Markets 2023," Photovoltaic Power Systems Programme, 2023, 8, https://iea-pvps.org/wp-content/uploads/2023/04/IEA_PVPS_Snapshot_2023.pdf.

2 For detailed data, see annual Snapshot Reports from the International Energy Agency's Photovoltaic Power Systems Programme at https://iea-pvps.org/snapshot-reports/.

3 Ibid.

4 International Energy Agency, "Snapshot of Global PV Markets 2023," 14. Germany's annual electricity demand exceeds that of Spain, Greece, and the Netherlands combined. See the International Energy Agency's Energy Statistics Data Browser at https://www.iea.org/data-and-statistics/data-tools/energy-statistics-data-browser?country=WORLD&fuel=Electricity%20and%20heat&indicator=TotElecCons.

5 Sladjana Djunisic, "South Korea Commits to Lower Renewables Target in Favour of Nuclear," Renewables Now, January 16, 2023, https://renewablesnow.com/news/south-korea-commits-to-lower-renewables-target-in-favour-of-nuclear-811471/.

Table 1: Top-10 Countries in Annual and Cumulative Installed Solar PV Capacity, 2022

	For Annual Installed Capacity			For Cumulative Capacity	
1	China	106.0 GW	**1**	China	414.5 GW
(2)	*European Union*	38.7 GW	**(2)**	*European Union*	209.3 GW
2	USA	18.6 GW	**2**	USA	141.6 GW
3	India	18.1 GW	**3**	Japan	84.9 GW
4	Brazil	9.9 GW	**4**	India	79.1 GW
5	Spain	8.1 GW	**5**	Germany	67.2 GW
6	Germany	7.5 GW	**6**	Australia	30.0 GW
7	Japan	6.5 GW	**7**	Spain	26.6 GW
8	Poland	4.9 GW	**8**	Italy	25.0 GW
9	Australia	3.9 GW	**9**	Korea	24.8 GW
10	Netherlands	3.9 GW	**10**	Brazil	23.6 GW

Source: International Energy Agency, "Snapshot of Global PV Markets 2023," Photovoltaic Power Systems Programme, 2023, 8, https://iea-pvps.org/wp-content/uploads/2023/04/IEA_PVPS_Snapshot_2023.pdf.

slight increase from the 9th Basic Plan's 2030 goal but also a significant reduction from the 30.2% target set for 2030 in South Korea's earlier Paris Agreement submission.[6] The 10th Basic Plan's overall goal is to move the country's future power mix toward nuclear and renewable generation with an assortment of power market reform and grid restructuring policies, such as establishing a low-carbon-only power market, introducing real-time ancillary service markets, implementing price-based pool systems and renewable power purchase agreements, and expanding distributed generation.[7] The government will continue to adjust the targets as it reassesses their feasibility and economic viability.

South Korea's National Assembly has recently passed legislation to encourage further solar PV deployment. Under the Special Act on the Promotion of Distributed Energy, the national government will identify "distributed energy specialized areas" where renewable power firms will be able to sell electricity directly to consumers rather than to the Korea Electric Power Company (KEPCO), a state-owned power generation and transmission utility.[8] In addition to creating opportunities for small-scale distributed power projects, the new law will allow selected

6 Ibid.

7 Ministry of Trade, Industry, and Energy, "10th Basic Plan for Power Supply and Demand" [in Korean], January 12, 2023, https://www.motie.go.kr/common/download.do?fid=bbs&bbs_cd_n=81&bbs_seq_n=166650&file_seq_n=1.

8 Invest Korea, "Jeju Island Strives to Become a Distributed Energy Specialized Area," May 30, 2023, https://www.investkorea.org/jj-en/bbs/i-1497/detail.do?ntt_sn=491338.

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localities greater control over their power systems. Other new regulations have been established to set different electricity tariffs regionally, based on the varying transmission and distribution costs. These are likely to improve competitiveness for distributed solar power systems in the future.

South Korea's annual installed PV capacity will likely decline further from 2022 to 2023. Higher interest rates have created obstacles for financing projects, as have reductions in feed-in tariffs and other policies supporting PV deployment.[9] In addition, South Korea's government has been investigating allegations that renewable energy subsidies were improperly allocated under the previous administration.[10] Notwithstanding these challenges, achieving the targets for solar PV's share in South Korea's power generation under the 10th Basic Plan will likely require annual installation of 4–5 GW in new capacity until 2036. This should contribute to faster growth in the country's domestic market in the coming years.

South Korea and the PV Supply Chain

The value chain for silicon-based solar PV has six steps. Silicon-based cells comprise 95% of the global solar PV market, in part because silicon is so widely available (after oxygen, it the most common element in Earth's crust).[11] Figure 1 illustrates the progression of the value chain for silicon-based solar PV, from polysilicon mining through ingot, wafer, cell, and module manufacturing. After mining polysilicon, manufacturers process it to form high-quality ingots for later use in making wafers, which are very thin plates of crystalline silicon with semiconducting characteristics. Wafers become solar cells, which can generate electricity from light, but are individually too small for most applications. Assembling cells into modules (by wiring them together and enclosing them for protection) allows for greater electrical output. Groups of modules form solar PV panels, which can be manufactured in various sizes (based on the number of modules) for end use within systems.

Solar PV systems incorporate additional components, such as inverters (to convert solar PV's direct current to the alternating current used in electricity grids). These components are sometimes referred to as balance-of-system (BOS) items, i.e., the parts other

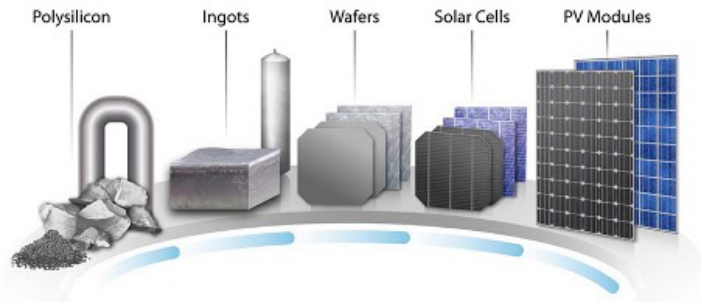
9 Emiliano Bellini, "South Korea Announces Results of Latest Nationwide Solar Inspections," PV Magazine, July 3, 2023, https://www.pv-magazine.com/2023/07/03/south-korea-announces-results-of-latest-nationwide-solar-inspections/.

10 Ibid.

11 US Department of Energy, "Solar Photovoltaic Cell Basics," https://www.energy.gov/eere/solar/solar-photovoltaic-cell-basics; Nicholas LePan and Bruno Venditti, "Visualizing the Abundance of Elements in the Earth's Crust," World Economic Forum and Visual Capitalist, December 14, 2021, https://www.weforum.org/agenda/2021/12/abundance-elements-earth-crust/.

than modules necessary to manufacture a complete solar PV system.

Figure 1: Silicon-Based Solar PV Value Chain



Source: National Renewable Energy Laboratory, "Solar Technology Cost Analysis," https://www.nrel.gov/solar/market-research-analysis/solar-cost-analysis.html.

Like solar PV manufacturing in other countries, South Korea's domestic solar PV industry has been hurt by China's emergence as the dominant global supplier of solar panels. China's share of global manufacturing was over 80% in 2022.[12] These impacts have been especially damaging to the earlier stages of the solar PV value chain (polysilicon, ingot, and wafer manufacturing), where South Korea's domestic supply chain has collapsed. Nevertheless, South Korea has sustained a modest share in global PV manufacturing with an annual contribution of about $5 billion to its trade balance during 2017–2021.[13] Cell and module manufacturing are critical to this; South Korea has held its place among the world's top-five solar PV module producers for several years.[14]

Export revenue from South Korea's solar manufacturing sector began to decline in 2018, due to severe global oversupply of solar PV. This oversupply was a consequence of China's massive investment in solar PV manufacturing, which China's government treated as a strategic sector,[15] and it led to decreases in shipments and reduced the profitability of South Korean firms. These trends were most challenging for polysilicon, ingot, and wafer manufacturers, who eventually halted domestic production.

Since 2019, however, South Korea's cell and module companies have dramatically improved their financial performance due to rapid growth in the domestic market and a rebalancing of supply and demand that has contributed to price stability in the global market. South Korean firms have also moved some operations overseas. This revitalization of the domestic PV market has established a foundation for longer-term competitiveness against Chinese companies. Overseas manufacturing grew rapidly in 2017–2021, as shown in table 2. While overall domestic employment in South Korea's PV manufacturing declined somewhat, rising revenue overseas has largely (though not fully) offset falling domestic revenue—and export earnings soared in 2021. Since then, the US Inflation Reduction

12 International Energy Agency, "Special Report on Solar PV Global Supply Chains," August 2022, 7, https://iea.blob.core.windows.net/assets/d2ee601d-6b1a-4cd2-a0e8-db02dc64332c/SpecialReportonSolarPVGlobalSupplyChains.pdf.

13 Ibid., 34.

14 Ibid., 28.

15 Ibid., 7.

Act has further stimulated South Korean solar PV manufacturing; most notably, Hanwha Q CELLS has announced a $2.5 billion investment to enlarge an existing plant and build a new facility, both in Georgia.[16]

Table 2: Employment and Revenue in South Korea's PV Manufacturing Industry

	2017	2018	2019	2020	2021
Domestic manufacturing jobs	7,522	7,732	7,567	7,761	6,654
Domestic revenue (billion KRW)	5,607	6,460	5,014	2,186	2,170
Overseas revenue (billion KRW)	829	1,325	1,837	2,169	2,839
Export revenue (billion US$)	3.2	2.6	2.3	1.4	1.0

Source: Korea Energy Agency, "Renewable Energy Industry Statistics 2022" [in Korean], 2023, https://www.knrec.or.kr/biz/pds/statistic/list.do.

Polysilicon, Ingots, and Wafers

As indicated above, Chinese companies' success in dominating the early steps in the solar PV value chain demonstrably harmed South Korean companies. The 2018 collapse of the polysilicon, ingot, and wafer steps in the solar PV value chain in South Korea effectively severed the value chain in the country. Today, South Korean firms primarily make cells, modules, and panels, often using Chinese wafers.

South Korean companies largely stopped producing ingots in 2017 and wafers in 2018; the Seoul Bankruptcy Court forced the last remaining domestic company producing ingots and wafers, Woongjin Wafer, to terminate its rehabilitation proceedings (thus forcing the company to shut down) in June 2022.[17] In 2018, officials assessed OCI, Hanwha Chemical, and other domestic companies for international competitiveness in producing polysilicon. Two years later, major domestic polysilicon-producing companies, including OCI, curtailed their operations.[18] Since 2021, OCI has been the sole South Korean company producing polysilicon for solar PV. It produces solar-grade polysilicon in Malaysia rather than domestically.[19]

Despite increasing global demand for solar PV installations and rising polysilicon prices, the value of South Korea's polysilicon exports has decreased since 2018. From 2021 to 2022, polysilicon exports decreased by 35.2%, to $61.7 million.[20] Facing

16 Marisa Mecke, "Korean Company Announces Largest Solar Investment in U.S. for Two Georgia Facilities," Savannah Morning News, January 11, 2023, https://www.savannahnow.com/story/news/environment/2023/01/11/hanwha-q-cells-announces-investment-in-georgia-solar-panel-manufacture/69795955007/.

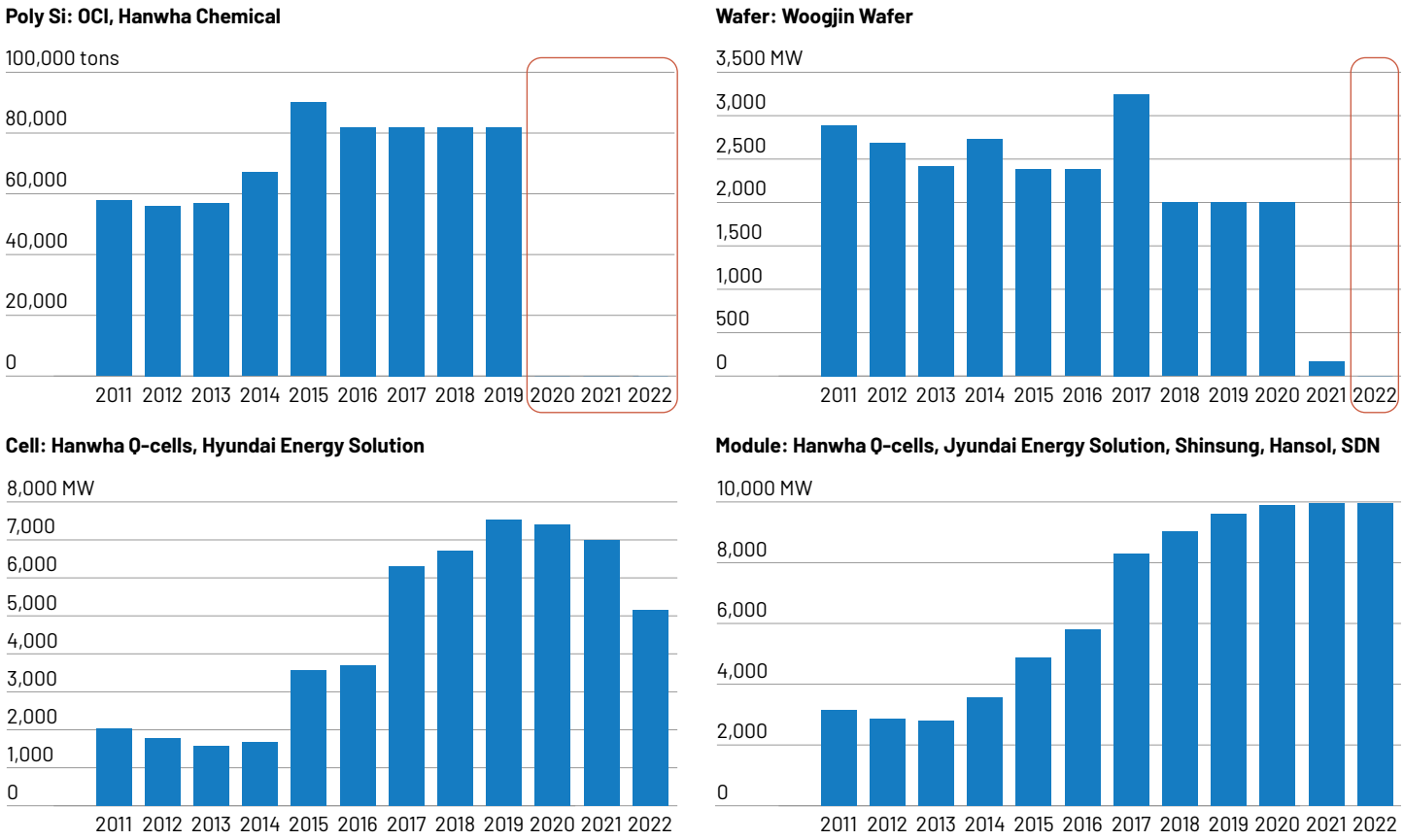
17 Jung Min-hee, "Korea's Solar Power Industry about to Collapse," BusinessKorea, July 20, 2022, http://www.businesskorea.co.kr/news/articleView.html?idxno=96884.

18 OCI shut down two production lines for solar-grade polysilicon in South Korea. See OCI, "History," https://oci.co.kr/eng/sub/company/history.asp.

19 OCI, "Polysilicon," https://oci.co.kr/eng/sub/business/poly.asp.

20 Export-Import Bank of Korea, "Photovoltaic Industry Trends in the First Half of 2023," [in Korean], July 5, 2023, 17–18, https://keri.koreaexim.go.kr/HPHFOE050M01/104297?curPage=1#none.

Figure 2: Manufacturing Capacity of Leading Firms in South Korea's Solar PV Value Chain



Source: Korea Photovoltaic Industry Association, http://www.kopia.asia.

financial losses as prices fell after 2019, South Korea's polysilicon companies have stopped domestic polysilicon production; as noted just above, OCI has outsourced its polysilicon production to Malaysia, thereby significantly reducing exports from South Korea. Some hope that given strong polysilicon prices, owners of domestic plants might decide to resume production; but uncertain future prices and new products from China make such decisions quite challenging, even with current prices that would permit profitable operations. In the United States, where firms are more confident about future demand,

Hanwha Solutions has invested substantially in Norwegian polysilicon producer REC Silicon.[21]

Figure 2 illustrates the collapse of South Korea's polysilicon, ingot, and wafer production and the partially offsetting growth in cell and module manufacturing. The upper left chart portrays the abrupt end of the country's domestic polysilicon production; the upper right chart shows the halt in wafer manufacturing. Growth in cell and module production is shown in the charts in the lower left and lower right, respectively.

Cells and Modules

Hanwha Solutions (Hanwha Q CELLS) and Hyundai Energy Solutions currently produce solar cells in South Korea with a combined capacity of 5.2 GW/year,[22] about 3.5% of the total global capacity. In 2021, they supplied 35% of solar panels installed in South Korea. Nevertheless, each has faced challenges in securing global market share. One challenge relates to the decision by Chinese firms, which dominate in the wafer sector,[23] to produce larger wafers;[24] this has in turn forced cell manufacturers to invest in new production equipment. LG Electronics announced its withdrawal from the solar business in 2022 despite technological advantages in high-efficiency solar modules.[25]

Another challenge for South Korean PV manufacturers is that Chinese companies—and specifically those that have achieved economies of scale—are investing aggressively in research and development. This has helped them establish and maintain a technological lead over South Korean and other global competitors.

About a dozen South Korean companies produce PV modules, including Hanwha Solutions (Hanwha Q CELLS), Hyundai Energy Solutions, and Shinsung E&G. The total production capacity of these companies is 9.4 GW/year, or 5.2% of the global market.[26] As in the solar cell sector, China's wafer-manufacturing dominance and its change in wafer sizes have forced new investment in module production equipment.

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21 Hanwha, "Hanwha Solutions Becomes the Largest Shareholder of 'Clean Polysilicon'; Manufacturer REC Silicon to Build a Green Solar Supply Chain," April 4, 2022, https://www.hanwha.com/en/news_and_media/press_release/hanwha-solutions-becomes-the-largest-shareholder-of-clean-polysilicon-manufacturer-rec-silicon-to-build-a-green-solar-supply-chain.html. REC Silicon has two US plants, in Washington and Montana. Only the Washington site produces solar-grade polysilicon.

22 Myung Seung Yeop, "Influx of N-Type Silicon Solar Panels . . . Increasing Investment in High-Efficiency N-Type Topcon and HJT Solar Panels" [in Korean], Industry News, March 3, 2023, https://www.industrynews.co.kr/news/articleView.html?idxno=48968

23 In 2022, China produced 97% of the global wafer supply. See Rob Schmitz, "China Dominates the Solar Power Industry. The EU Wants to Change That," NPR, May 17, 2023, https://www.npr.org/2023/05/17/1173250926/solar-power-eu-germany-china.

24 China's wafer sizes have repeatedly increased in recent years. See Kelly Pickerel, "More Solar Panels Are Switching to Bigger Wafers," Solar Power World, January 20, 2021, https://www.solarpowerworldonline.com/2021/01/more-solar-panels-are-switching-to-bigger-wafers/.

25 LG, "LG to Close Solar Panel Business," February 23, 2022, https://www.lgnewsroom.com/2022/02/lg-to-close-solar-panel-business/.

26 Export-Import Bank of Korea, "Photovoltaic Industry Trends in the First Half of 2023," 9.

South Korean firms also depend heavily on Chinese suppliers for most other module materials and components, including backsheets, glass, aluminum frames, junction boxes, and so on.[27] In 2021, only 66% of the modules supplied to South Korea's domestic PV installation market were domestic products.[28]

From 2021 to 2022, the value of South Korea's solar panel and module exports increased by 43.7%, reaching $1.55 billion.[29] The United States accounted for 92.2% of exports by value, at $14.3 billion, followed by the Netherlands ($350 million), China ($210 million), Angola ($170 million), and Australia ($110 million).

South Korea's solar exports to the United States have benefited significantly from a trade dispute between the United States and China. As a result of this dispute, primarily related to government subsidies that have allowed Chinese firms to undersell their competitors, Washington has imposed high tariffs on Chinese solar products. America has also blocked some Chinese solar products from the US market due to human rights concerns.[30] In addition, the United States now offers tax benefits for installing and operating solar PV systems in the United States through the Inflation Reduction Act, which has encouraged export of components for assembly in America, such as in the plants in Georgia being expanded or built by Hanwha Q CELLS.[31]

Europe has not imposed comparable tariff barriers for Chinese products; consequently, South Korea's solar products have faced deteriorating competitiveness every year. In Europe today, non-Chinese products are approximately 20% more expensive than Chinese products;[32] this situation has undermined exports to the European market and has in turn eroded the total value of South Korea's solar PV exports to Europe over time. Without new measures to boost their competitiveness, South Korea's solar PV exports appear set to decline everywhere other than the United States in the coming years, despite expanding global demand for solar energy systems.

PV Systems and BOS Components

Inverters are one of the most important components in a solar PV system, as inverter efficiency affects the system's overall efficiency. The impact of inverters

27 International Energy Agency, Special Report on Solar PV Global Supply Chains, 28.

28 Yeop, "Influx of N-Type Silicon Solar Panels."

29 Export-Import Bank of Korea, "Photovoltaic Industry Trends in the First Half of 2023," 18.

30 In 2021, the United States enacted a law banning products made with forced labor in China's Xinjiang Uyghur Autonomous Region, Public Law No. 117-78, https://www.congress.gov/bill/117th-congress/house-bill/6256. US officials have said that almost half of the world's polysilicon originates in Xinjiang, with some produced using the forced labor of China's Uyghurs and other Muslim minorities. For a summary, see US Department of Labor, "Traced to Forced Labor: Solar Supply Chains Dependent on Polysilicon from Xinjiang," https://www.dol.gov/sites/dolgov/files/ILAB/images/storyboards/solar/Solar.pdf.

31 Firms can obtain either an investment tax credit (for installation) or a production tax credit (for power generation), but can be eligible for bonus credits if the systems meet domestic content requirements.

32 Park So Yeon, "Korea's 'Domestic Solar Panels' to Shine with Technological Prowess as Price Competition against China Proves Challenging," MoneyToday, July 23, 2020, https://news.mt.co.kr/mtview.php?no=2020072218535356776.

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is particularly important in that cell and module efficiencies vary within a relatively narrow range.[33] Manufacturers compete to make more efficient systems, which produce more electricity than less efficient systems at the same size and cost. Thus, firms strive to manufacture more efficient inverters in addition to more efficient cells and modules.

South Korean inverter manufacturers, including DASS Tech, Hexpower, and Willings, rely entirely on silicon power semiconductors imported from China and other countries. At the same time, Chinese companies are developing high-efficiency, low-power-consumption inverters to increase their market share in South Korea and elsewhere. Recent developments in MLPE (module level power electronics) micro-inverter technology may increase power conversion efficiency further, in part by better addressing variation in output across modules in an installation (arising for example, from the modules' placement in shade or not). Further technological development will be needed to ensure climate reliability, stability, and grid interconnection standards.

Friend-shoring of PV Supply Chains

China's dominance in the global solar industry poses a considerable challenge to South Korea's efforts to expand its firms' global market share. At the same time, policies to encourage domestic manufacturing of clean energy technologies, such as the EU's Green Deal and the US Inflation Reduction Act, are encouraging substantial South Korean investment in new production facilities in Europe and the US. Indeed, US president Joseph Biden has welcomed the Hanwha Q CELLS investment in Georgia as the largest solar investment in America's history.[34]

Moreover, the United States and the EU are not alone in seeking to boost their domestic industries. In 2020, India established a Production Linked Incentive program to support domestic industries in 10 sectors, including high-efficiency PV modules.[35] China has announced a wide range of policies to expand its domestic solar market and manufacturing and to sustain its predominant global role. This includes massive state investments to develop manufacturing and stimulate demand;[36] export restrictions on

33 In 2021, most commercially available solar PV modules were 15–20% efficient, though newer technologies have increased these levels somewhat. See University of Michigan Center for Sustainable Systems, "Photovoltaic Energy Factsheet," https://css.umich.edu/publications/factsheets/energy/photovoltaic-energy-factsheet.

34 The White House, "Statement from President Joe Biden on Hanwha Q CELLS Announcement," January 11, 2023, https://www.whitehouse.gov/briefing-room/statements-releases/2023/01/11/statement-from-president-joe-biden-on-hanwha-q-cells-announcement/.

35 Press Information Bureau, Government of India, "Cabinet Approves PLI Scheme to 10 Key Sectors for Enhancing India's Manufacturing Capabilities and Enhancing Exports – Atmanirbhar Bharat," November 11, 2020, https://pib.gov.in/PressReleasePage.aspx?PRID=1671912.

36 Sara Schonhardt, "China Invests $546B in Clean Energy, Far Surpassing U.S.," E&E News, January 30, 2023, https://subscriber.politicopro.com/article/eenews/2023/01/30/china-continues-to-dominate-clean-energy-investment-00080013.

large silicon, black silicon, and cast-mono silicon technologies;[37] and (most recently) new export permit requirements for gallium and germanium, which are used in semiconductors and solar panels.[38]

In comparison with similar efforts in other nations, the US Inflation Reduction Act is especially consequential for South Korea's domestic PV industry. South Korean PV companies that manufacture equipment in the US market can benefit from increased sales as the law's tax credits spur demand. Greater demand can in turn contribute to economies of scale that reduce costs and improve competitiveness in emerging markets outside the United States and Europe.

Yet there is also a downside to South Korean companies' construction of new manufacturing capacity in the United States: it is hollowing out South Korea's domestic PV industry. Outbound transfer of capital and technology to the United States may undermine South Korea's domestic solar PV industry. Protecting the domestic PV industry requires not only cooperation between domestic companies and those that have outsourced substantial manufacturing to the United States; it also requires collaboration by the US and South Korea to secure a global competitive edge in solar energy value chains.

We see US–South Korean collaboration in solar PV value chains—that is, friend-shoring—as a highly desirable strategy for both countries.

- Friend-shoring stabilizes supply chains by ensuring reliable supplies of silicon materials and other essential components. This helps mitigate vulnerabilities in the global supply chain and enhances the industry's stability.

- Friend-shoring provides opportunities to enhance competitiveness through collaboration with various countries and regions rather than reliance on national-level efforts. This allows companies to utilize diverse markets and sources of supply to pursue flexibility and diversification.

- Friend-shoring can improve technological innovation and knowledge sharing. Through international collaborative research and cooperation projects, it promotes the development of new technologies and facilitates the exchange of experiences and knowledge, contributing to the industry's growth.

37 Jeff Pao, "China Bans Export of Core Solar Panel Technologies," Asia Times, February 1, 2023, https://asiatimes.com/2023/02/china-bans-export-of-core-solar-panel-technologies/.

38 Camila Domonoske, "China Imposes Export Controls on 2 Metals Used in Semiconductors and Solar Panels," NPR, July 4, 2023, https://www.npr.org/2023/07/04/1185940293/china-imposes-export-controls-on-two-metals-used-in-semiconductors-and-solar-pan.

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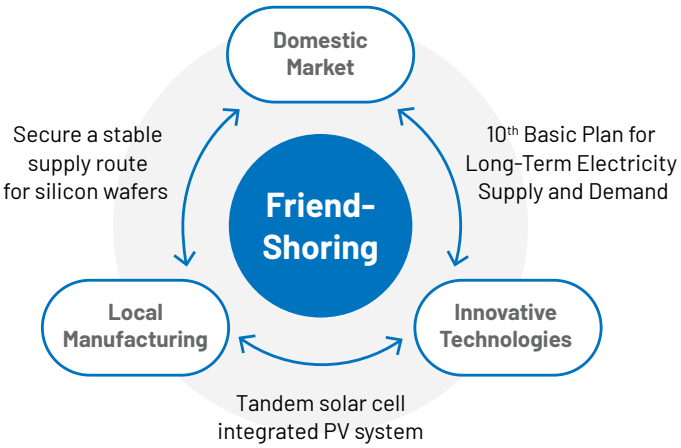
Figure 3 illustrates the centrality of friend-shoring to South Korea's domestic market, domestic manufacturing, and innovation.

Figure 3: Friend-shoring as the Core of South Korea's Solar PV Industry



Source: Authors.

Recommendations

We recommend the following policy directions for South Korea's PV industry:

1. **Participate actively in a US-led friend-shoring effort, while considering Korea's national interests.**

   - Secure a stable supply route for silicon wafers by building new global supply chains that depend less on China. Hanwha Q CELLS can play a key part in this effort through its US manufacturing. South Korean government support for a wafer factory at OCI's polysilicon plant in Malaysia could also contribute. Investment and tax incentives would likely be required to support South Korean manufacturing.

   - Pursue bilateral South Korean–US research and development cooperation to regain the technological lead in solar PV. Possible areas for cooperation could include developing perovskite-based tandem cell technologies and integrated module technologies.

2. **Expand South Korea's domestic solar PV market.**

   - Accelerate solar PV deployment to achieve targets set in the 10th Basic Plan.

     - Remove burdensome regulations that slow deployment.

     - Provide incentives for system deployment.

- Support domestic companies in achieving their renewable power goals through promotion of power purchase agreements and policies to reduce solar PV's levelized cost of electricity in South Korea, especially soft costs such as acquisition and land use fees.

- Secure a stable 3–5 GW annual domestic PV installation market to sustain domestic PV manufacturing.

- Enhance and diversify South Korea's carbon certification system and link it with the emissions trading systems.

3. **Support domestic manufacturing, particularly in medium-size innovation-based PV enterprises that could become "unicorns."**

   - Provide new government incentives for medium-size module manufacturers and innovation-based technology companies that produce integrated PV modules for building-integrated PV (BIPV), floating PV (FPV), agri-PV (APV), and other specialized applications.

   - Provide manufacturing support and incentives for companies producing small quantities of diverse products to encourage innovative research, development, and production in specialized areas that can serve future niche markets.

   - Leverage domestic core industries such as petrochemicals, steel, and semiconductors to boost competitive advantage in the domestic solar PV manufacturing industry.

4. **Promote innovation**.

   - Include solar PV in the nation's strategic core technology list.

   - Accelerate innovation in areas such as tandem solar cells and integrated PV systems.

   - Foster key material, component, and equipment companies that could drive the future solar market, perhaps including manufacturers of durable packaging materials and dry-processed perovskite materials deposition equipment.

About the Authors

Jae Ho Yun is a professor at KENTECH and vice president of the Korea Photovoltaic Society. From 2020 to 2021, he was chief of the Photovoltaic Research Department at the Korea Institute of Energy Research, where he led research on solar energy and other new and renewable energy from 2011 to 2021.
Chinho Park is a distinguished professor at KENTECH and former president of the Korea Energy Society. He was managing director for the energy industry in the Ministry of Trade, Industry, and Energy Office of Strategic R&D Planning from December 2016 to December 2019. He is a former president of the Korea Photovoltaic Society.