

# How Solar Developed from the Bottom-Up in China

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*China's solar industry started as an export-oriented sector driven primarily by local government investments in manufacturing capacity. Although the central government has taken a more active role in shaping domestic markets since its first intervention in the solar industry in 2009, it has continued to primarily address unintended consequences caused by misaligned incentives for subnational actors.*

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## Three Periods of Industrial Policies for China's Solar Industries

Despite frequent claims that China's rise in global solar photovoltaic (PV) industries was the realization of strategic central government industrial policy, the development of China's solar PV sectors initially followed a bottom-up pattern. Its developmental patterns can be understood in three distinct stages. First, until the 2009 financial crisis, China's solar PV industry primarily developed as an export-oriented manufacturing policy with the support of subnational governments. Second, after the financial crisis led many governments in Europe to remove subsidies for solar PV installation, China's central government intervened with the creation of domestic solar markets to save a now sizable solar PV industry. Third, beginning in 2015, and somewhat unsuccessfully, the Chinese central government began removing domestic subsidies and again focused on technological efficiency, production cost, and grid integration in its treatment of the domestic solar PV industry.

The case of solar is unusual in that the initiative to grow an entire industrial sector resulted almost entirely from local government action, at least initially without guidance or input from central government actors. The center never

fully managed to gain control of the sector. Even as it began to intervene in the solar industry in 2009, it continued to primarily address unintended consequences caused by misaligned incentives for subnational governments, which frequently resulted in overcapacity.

## The Export Origins of China's Solar PV Sector, 2000–2009

In contrast to other new energy industries in China, which were often dominated by state-owned enterprises that entered these sectors following central government directions, most of China's early solar firms were established by returning entrepreneurs. Solar firms were frequently founded by Chinese scientists educated in solar PV research laboratories abroad, in particular at the University of New South Wales (<https://www.crikey.com.au/2013/03/21/the-power-index-carbon-cutters-bureaucratic-troika-at-1/>) in Australia.

Rather than relying on licensing and joint development agreements, as was prevalent in other high-technology sectors in China, China's foreign-trained researchers returned to their hometowns and indigenously developed solar PV technologies, drawing on government funding. Also, Chinese solar PV technology came from installing American- and European-manufactured equipment embedded with critical technologies. This allowed Chinese manufacturers to produce solar PV products without having to develop core technologies in-house.

Chinese solar PV firms excelled in bringing these cell technologies to mass production. Even though Chinese laboratories generally lagged in solar PV conversion efficiencies achieved under laboratory conditions, as early as 2007, Chinese solar PV companies were mass-producing solar modules with cell efficiencies (<https://global.oup.com/academic/product/collaborative-advantage-9780197555361?cc=us&lang=en&>) on par with or better than those of their competitors.

However, a lack of central government subsidies for domestic solar PV deployment prevented domestic solar markets in China, requiring Chinese solar PV manufacturers to export more than 90 percent of their production. This contrasts with the wind industry, for which China's central government introduced subsidies (<https://www.sciencedirect.com/science/article/pii/S0301421599000774>) and other demand-stimulating policies (<https://www.sciencedirect.com/science/article/pii/S0301421511010305>), for domestic markets as early as 1997.

## Creating Domestic Demand but Exporting Anyway, 2009–2015

The 2008/2009 financial crisis put an end to generous subsidies that had created demand for Chinese solar panels in several European export markets. Chinese solar PV manufacturers, which had to date exported most of their products to European markets and had grown into a sizeable

industrial sector, were suffering rapidly declining sales. At the same time, cost declines because of scale economies and cut-throat competition had made once uncompetitive solar PV technologies more and more affordable.

In the context of broader economic stimulus efforts, China’s central government for the first time created incentives for domestic solar demand. Notable in the case of solar is that such central government efforts to shape and support the industry came after nearly a decade of development primarily driven by private sector initiative and subnational government support. Starting in 2009, a first nationwide central government subsidy for solar energy sold to the electric grid subsequently created a small but growing domestic market for solar PV technologies. Additional direct subsidy programs were [available \(https://sgp.fas.org/crs/row/R41748.pdf\)](https://sgp.fas.org/crs/row/R41748.pdf) to support both the installation of residential and utility-scale solar PV installations. However, these subsidies took a while to take effect—it was not until 2012 that central government support at last led to growing domestic markets. Until then, China’s solar PV firms continued to export the vast majority of their production.

The inclusion of solar PV on the list of strategic emerging industries in 2010 and the goals set in the 12<sup>th</sup> Five-Year Plan (2011–2015) for the solar industry greenlighted subnational government plans to support their local solar firms. As a result, China’s solar firms had access to large sums of capital through bank loans, provided by state-owned banks and frequently guaranteed by local government entities or state-owned companies.

Credit lines to expand manufacturing capacity were brokered and backed by local governments and state-owned firms, even in the years after the global financial crisis when the collapse particularly of European markets led to overcapacity in global solar markets. Providing loans was a way to improve local GDP growth rates, employment rates, and other indicators of economic development used to determine cadre performance and promotions. Solar PV’s status, first as a designated high-technology sector, and, starting in 2010, as a strategic emerging industry in central government plans further encouraged local government officials and state-owned banks to continue lending to China’s solar PV sector.

The incentives for government officials to support the expansion of manufacturing capacity of local firms and the ability of firms to draw on financial support and bank loans to fund such expansions permitted solar PV firms to increase their manufacturing capacity, even during periods of overcapacity in global solar PV markets.

The mismatch between production capacity and market demand suggests that subnational governments envisioned solar PV sectors primarily as export-oriented industries over the course of the 12<sup>th</sup> Five-Year Plan period (2011–2015).

	2000–2009	2009–2015	2015–present
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<b>Role of central government</b>	Government created domestic solar market through subsidies; inclusion of solar PV as a strategic emerging industry and listed in the 12 <sup>th</sup> Five-Year Plan (2011–2015)	Government created domestic solar market through subsidies; inclusion of solar PV as a strategic emerging industry and listed in the 12 <sup>th</sup> Five-Year Plan (2011–2015)	Central government began to remove domestic subsidies, pushing technological efficiency, production cost, and grid integration; ad hoc policies to increase the role of domestic markets; Top Runner program started in 2015
<b>Funding</b>	Support of subnational governments	Increased access to bank loans, expanding local capacity for support and expansion	Several incentives for subnational government investments were removed
<b>Subsidies</b>	EU government subsidies for solar PV installation	EU subsidies reduced; central government subsidies announced in 2009 and implemented in 2011	Central government reduced domestic subsidies
<b>Demand focus (export/domestic)</b>	Export-oriented manufacturing policy	Domestic growth but subnational governments largely envisioned solar PV sectors as export-oriented	Further increased the role of domestic markets

<b>Level of production</b>	Domestic installation was less than 2% of production; exported more than 90% of production	Increasing domestic focus but a vast majority of production was exported; domestic installation was 4% of production in 2010 and 15% of production in 2013; 55% of production was exported in 2013; overproduction	In 2021, China accounted for 36 percent of solar demand, but 97 percent of wafer, 75 percent of module, and 85 percent of cell manufacturing.
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### Reducing Dependence on Public Support, 2015–Present

Beginning in 2013, the central government began to intervene more aggressively to manage the overcapacity that had begun to build in China's domestic solar industry, both because of continued investment in additional manufacturing capacity and insufficient demand in both domestic and international markets. Central government interventions during this period primarily focused on shaping domestic solar PV markets to both encourage scale and continued investments in technological innovation among domestic solar firms. Policies tended to be ad hoc responses to ever new problems growing out of the activities of subnational governments. The immediate focus of central government policies was to further increase the role of domestic markets.

To manage the growing cost of subsidies paid to solar energy generators through a bonus payment on top of regular electric prices, the National Development and Reform Commission in 2015 announced that it would begin lowering subsidy rates, starting in December of the same year. Subsidies created windfall profits for renewable energy developers as the cost of solar PV technologies continued to decline, and the central government sought to align subsidies with falling technology costs in a series of steps. Solar subsidies were lowered year over year. Despite such reductions, China reached its 2020 solar installation targets three years ahead of schedule, prompting the decision in the central government to wean the industry off demand-side subsidies altogether and move to a bidding system (<https://iopscience.iop.org/article/10.1088/1755-1315/651/2/022050>) for new installations.

In 2015 the central government launched a so-called Top Runner program ([https://www.pv-magazine.com/magazine-archive/insight-chinas-top-runner-pv-program\\_100023185/](https://www.pv-magazine.com/magazine-archive/insight-chinas-top-runner-pv-program_100023185/)). Top Runner projects injected incentives to deploy advanced solar PV technologies and retire the production of dated

technologies. Module cost continued to fall because of these incentives, while module efficiency continued to increase. Particularly installations of high-efficiency panels in Western China were able to achieve grid parity because of those incentive changes, yet broader issues, including the perpetual underfunding of the renewable energy fund, the low profitability of domestic manufacturers, overcapacity, and broader trade tensions remained unresolved.

## Conclusion

In contrast to industries such as wind power, and to some extent electric vehicles, where central government policy used domestic markets strategically to build technological know-how and weed out nonperforming firms, the Chinese solar industry started as an export-oriented sector driven by local government investments in manufacturing capacity.

While the center enabled the role of subnational actors to some degree—not least by designating solar a strategic emerging industrial sector, which allowed local administrations to turn on the spigot of policy lending for manufacturing expansion—the center responded to local actions more than it guided them. Subnational investments created a dilemma for the center in 2009, when export markets collapsed in the wake of the global financial crisis and even China’s highest-performing solar firms were hanging on by a thread. China responded with incentives to drive domestic demand and avoid the looming wave of bankruptcies.

While the central government has taken a more active role in shaping domestic markets since its first intervention in the domestic solar industry in 2009, it has continued to primarily address unintended consequences caused by misaligned incentives for subnational actors. Investments in production capacity expansion continued to trail growing domestic demand, even as generous feed-in tariffs offering subsidies based on the solar resources available in each province were slow to adjust to falling prices and created rapidly accelerating domestic installations.

China succeeded in solar primarily by unleashing unprecedented capital investments for manufacturing expansion using practices grounded in the local developmental state of the 1990s. Rather than be an example of strategic industrial policy intervention, China’s solar PV industry is a study in addressing unintended consequences without fixing their underlying causes.

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