Facilitating, Enabling, and Triggering Sectoral Transitions: India

Demand Support Policies

Case Study 16. Solar Power in India

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Context

India's energy system is on the cusp of a paradigm shift toward renewables, driven by a concerted policy effort to spur wide-scale solar adoption. Growing from 4 to 13 percent of total electricity generation between 2014 and 2022 and projected to account for 30 percent of generation capacity by 2040, India's solar energy sector is rapidly growing (figure 3.14; IEA 2021b, 2022e; Ministry of Power 2022). Since 2004, $130 billion has been invested in India's RE sector. Of this, solar energy accounts for $71 billion, and its share of the country's renewable investment portfolio has risen from insignificant levels to 83 percent (figure 3.15; BloombergNEF 2022).

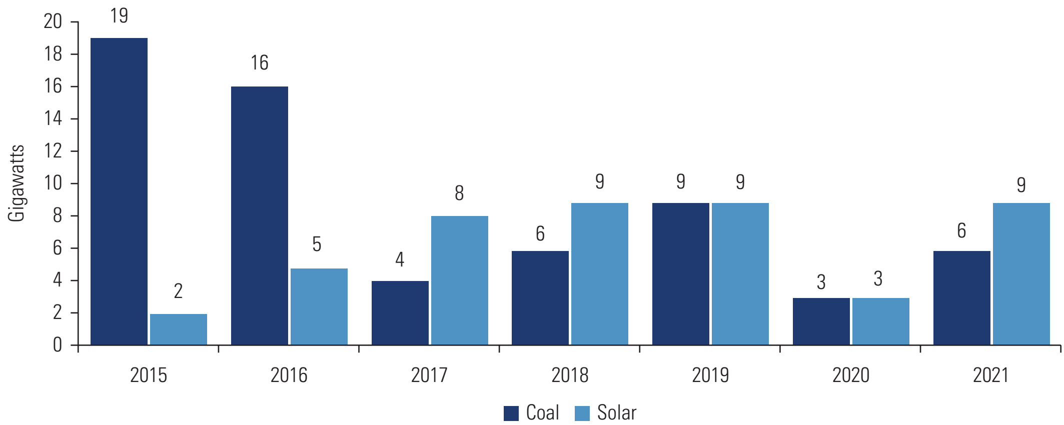
India's fast-growing economy and population have led to increased demand for energy services. Catalyzed by improved living standards, 40 percent population growth, increasing electrification, and advancing vehicle ownership, India's primary energy demand has doubled from 5,000 to 10,000 terawatt hours (TWh) in the past two decades. It is the third-largest energy consumer globally and projected to account for one-quarter of global energy demand growth between 2019 and 2040 (IEA 2020b).

To meet this demand, the government has prioritized utility-scale solar systems, home solar systems, and mini-grids for last-mile electricity connectivity in rural communities through an enabling political and economic framework. India has vast solar energy resources, with nearly 750 gigawatts (GW) of potential (Bandyopadhyay 2017). Since 2010, the government has prioritized solar energy as part of its economic transformation agenda, using favorable policies such as RE targets, fiscal incentives, FiTs, and reverse auction mechanisms (figure 3.16; *Economist* 2022).

Policy

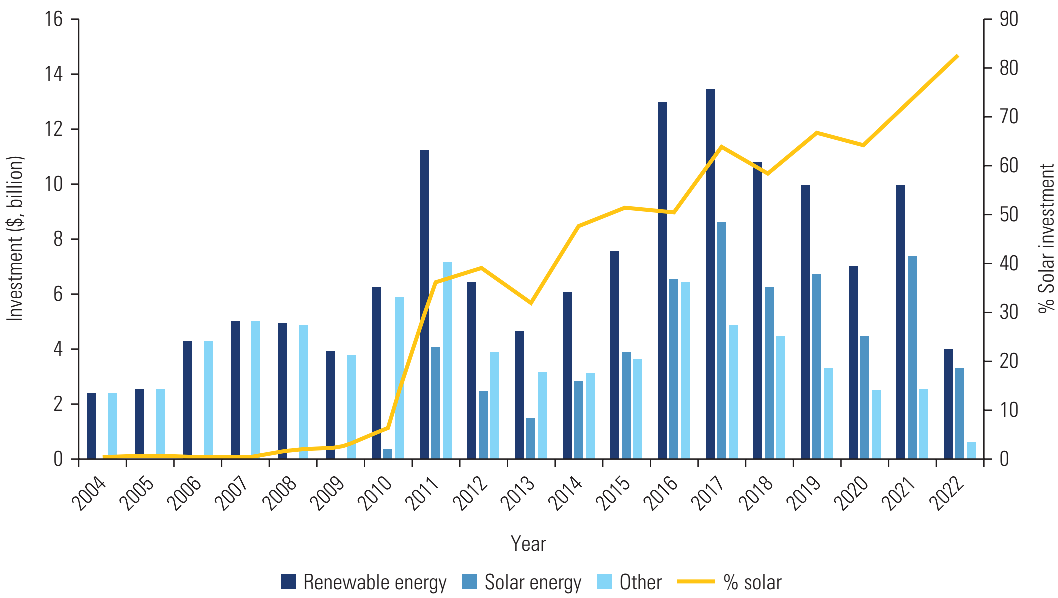
India identified energy and climate challenges and set RE targets, backed by government programs and planning, as leverage points to solve its problems. As a first step, the government set out the National Action Plan for Climate Change in 2008 (Raina and Sinha 2019), creating initiatives with measurable objectives to advance the solar energy goal under the action plan. It introduced the National Solar Mission (NSM) in

FIGURE 3.14 New Annual Energy Capacity Additions, in Gigawatts, 2015–21



Source: Jaiswal and Gadre 2022.

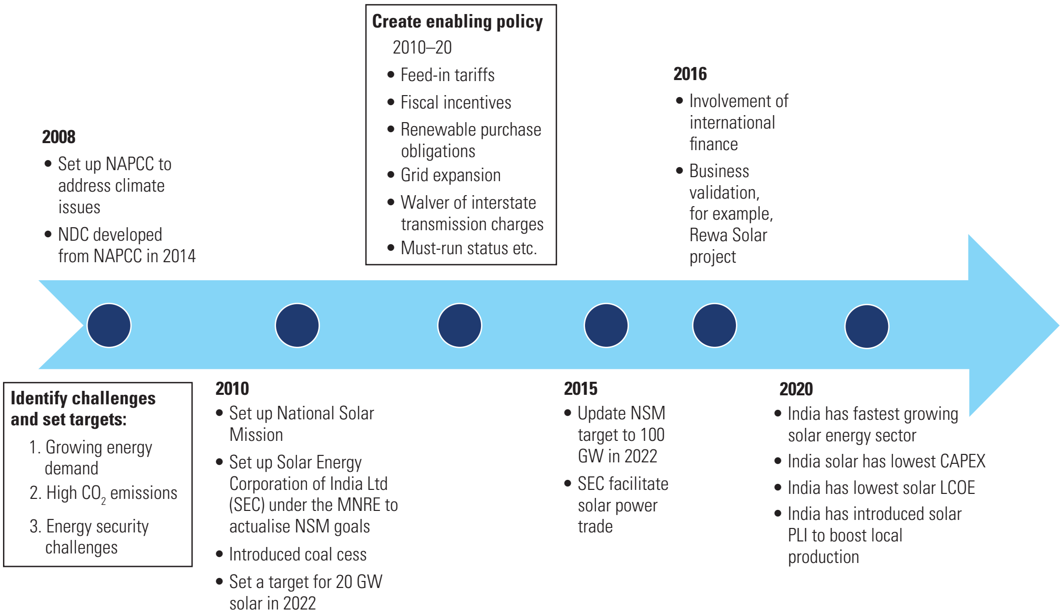
FIGURE 3.15 Renewable Energy Investment in India, 2004–22



Source: BloombergNEF 2022.

2010 to develop other supporting systems for solar energy advancement, tasking the Ministry of New and Renewable Energy with implementing it. It has targeted achieving 500 GW of nonfossil energy capacity by 2030 in its NDC and 30 percent solar energy contribution to the electricity mix by 2040 in the 2070 Net-Zero plan announced by Prime Minister Narendra Modi at the 26th United Nations Climate Change Conference of the Parties (COP26) in Glasgow (Government of India 2014; IEA 2020b).

FIGURE 3.16 India's Solar Energy Expansion—Key Milestones



Source: BloombergNEF 2022.

Note: CAPEX = capital expenditures; GW = gigawatts; LCOE = levelized cost of energy; MNRE = Ministry for New and Renewable Energy; NAPCC = National Action Plan for Climate Change; NDC = nationally determined contribution; NSM = National Solar Mission; PLI = Production-Linked Incentive Scheme.

Fiscal policies and financial incentives have helped enhance RE investment. In 2010, the government created the National Clean Energy Fund through a *cess* (fee) on coal (originally $0.75/metric ton, revised to $5.7/ton in 2016) to support the nascent solar energy sector by creating initial capital for RE (IISD 2018). The federal and state governments alike have also provided other fiscal incentives, including solar project subsidies and tax incentives. For example, in the 2019 Pradhan Mantri Kisan Urja Suraksha evam Utthan Mahabhiyan scheme, many state governments agreed to provide 30 percent subsidies to deploy 10 GW solar energy plants. Accelerated depreciation tax benefits for developers also featured prominently in India's solar energy strategy, allowing them to depreciate RE assets at much higher rates than general fixed assets and claim tax benefits on each year's depreciated value. Between 2014 and 2017, the rate was set at 80 percent; this was revised to 40 percent in 2017.

In addition, the Government of India's NSM provided demand and technology support and policies for tariff and capacity building. These include the following:

- Interstate Transmission System charge waivers
- Dedicated solar parks for new projects, to address delays and difficulties in land acquisition caused by complex land permits, a lack of clarity over land titles, outdated records, and fragmented landholdings (Behuria 2020; IEA 2020b, 2021d; Raina and Sinha 2019)

- Reverse auctions to encourage competitive bidding and reduce solar energy tariffs
- State-dependent FiTs of $0.16–0.36 per kilowatt hour (kWh), and net metering, which credits solar energy owners based on surplus energy exported to the grid
- Renewable purchase obligations for utilities to buy 10.5 percent of their electricity from solar sources by 2022
- Must-run status policy, prioritizing the purchase of RE over fossil energy by grid operators
- Working with the International Solar Alliance to offer financial analysis of solar energy proposal training for financial institutions.

Although the national government retained control over long-term strategy, state governments played a critical role in engendering the transition:

- Signing solar power purchase agreements to encourage investment and facilitating the purchase of renewable electricity
- Facilitating land selection and approval and providing infrastructure for solar parks for projects
- Supporting interstate transmission through right-of-way access and environmental clearances
- Providing youth skills training to build technical competency for solar jobs (NRDC 2016).

Supported by these policies, the private sector and international financial agencies provided business models for bankable solar investment. Solar assets have historically been considered risky due to their high up-front costs, long payback periods, and project uncertainties (Sarangi 2022). As a result, banks offered high-interest rates for solar projects, making it difficult to access private capital. To address this, international financial institutions provided scalable PPP models, as in the case of the 750 MW World Bank–financed Rewa Solar Park in Madhya Pradesh, a flagship solar project that powers a metrorail line serving more than 2.6 million commuters a day. The World Bank provided technical and financial support in the form of concessional credits that improved investor confidence, while the state provided institutional support, including land and payment security. Overall, the project achieved tariffs that were 24 percent lower than the previous lowest national subsidy-free tariff (IFC 2020).

Results and Impacts

Thanks to this conducive policy environment and the global decline in solar energy costs, India's solar energy transition is underway. The up-front capital expenditure for utility-scale solar in India has decreased significantly, making India one of the cheapest places to deploy grid-scale solar power in the world. The attractiveness of India's solar sector has led to a $71 billion capital inflow over the past two decades, increasing solar installations from 65 MW in 2010 to more than 57 GW capacity in 2022 (table 3.4; IEA 2020b, 2022e; Ministry of Power 2022).

TABLE 3.4 Key Results of India's Solar Energy Expansion Drive

Objective	Results
Reduced up-front capital expenditure solar	$5,000/kW (2010)[a] $596/kW (2020)[a]
Reduced levelized cost of solar energy	$0.17/kWh (2010)[a] $0.038/kWh (2020)[a] 34% less than the global average[a]
Increased renewable investment	$71 billion since 2000[b]
Higher deployment and increased solar capacity targets	100 GW solar target for 2022[c]

Sources: BloombergNEF 2022; IEA 2022e; IRENA 2021.

Note: GW = gigawatts; kW = kilowatts; kWh = kilowatt hours.

a. Data from IRENA 2021.

b. Data from BloombergNEF 2022.

c. Data from IEA 2022e.

The increased deployment of solar has resulted in avoided CO_2 and air pollutant emissions, improved electricity access, and created jobs. With a carbon footprint of 4 to 6 grams of CO_2 per kWh, compared with the power grid's 718 grams of CO_2 per kWh (Ritchie and Roser 2022), solar power can reduce India's emissions by 1 $GtCO_2e$ by 2030, in line with its climate targets. Solar systems also improve electricity access: government-backed programs have provided 3.4 million solar lamps, more than 350,000 solar home systems, and mini-grids for last-mile electricity connectivity in many rural communities (Zaman, van Vliet, and Posch 2021). The sector has also created green jobs, with solar PV-related jobs in India reaching 163,500 in 2020 (IRENA 2021).

Key Takeaways

India shows how countries can achieve rapid scale-up of climate-smart solutions by leveraging the strengths of different stakeholders. The government prioritized the sector by setting a bold national target and provided both a stable policy ecosystem and a timely and adequate set of incentives. Development finance institutions provided concessional financing to kick-start the market and backed private investments by appropriating the necessary risk mitigation instruments. Finally, the private sector invested in India's solar energy scale-up and embraced technological advancements.

India aims to grow domestic solar manufacturing. In 2017, the largest bilateral solar export flow was from China to India, valued at $2.72 billion (Wang et al. 2021). Understanding the supply chain issues that emerge from India's dependence on China for solar cells, including transportation and shipping, which increase solar power costs and the increased geopolitical risks of energy security caused by import dependence (Shiradkar 2022), and in line with its plan to create green jobs, the government of India has earmarked funding for PV manufacturing as part of its $26 billion Production-Linked

Incentive (PLI) scheme (ET Bureau 2021). Of this, $2.6 billion will be made available to catalyze the development of domestic solar manufacturing for plants with more than 1 GW capacity (Rai-Roche 2022).

To address RE intermittency and storage requirements, the national government has set out initiatives to improve grid robustness. In 2013, the country achieved full regional power system connectivity. In 2015, it designed the Green Energy Corridor Policy to synchronize RE generation with conventional power stations in the grid. Under these policies, there was significant investment in grid capacity expansion, with a revised target of 9,700 circuit kilometers to export 20 GW of RE generation by 2022 (MNRE 2022). This national government, state equity, and loan-funded scheme has surpassed its target, adding 9,767 circuit kilometers. Other targets include increasing capacity from 75 GW in 2017 to 118 GW in 2022. The government is also harnessing battery and hydropower storage for ancillary market services and sponsoring research into new and more viable battery storage technologies. In 2021, it announced plans to float 4,000-megawatt hour (MWh) grid-scale battery storage tenders. These efforts have positively affected energy trade volumes and renewable power distribution and decreased blackouts due to low grid capacity, setting the stage for future expansion.

Rapid power sector transition will cause more grid operational constraints. To address these challenges, demand and supply-side flexibility, grid flexibility, storage, and power market frameworks will be needed. The government should therefore build a pricing mechanism and accelerate the rollout of advanced metering infrastructure to incentivize active participation in energy consumption and match peak production and consumption. It is possible to remove regulatory barriers to battery and hydro storage deployment by providing the proper remuneration framework for distributed storage projects to incentivize further investment. The government can also introduce measures to enhance interstate energy trade. In the long term, it can research innovative systems, such as EVs for storage using the vehicle-to-grid framework. Finally, with the reduced cost of solar power in India, the government can prioritize research into integrating solar-powered electrolyzers to produce green hydrogen for reliable short- and long-term storage that can improve India's grid robustness.