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India's Solar Journey

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India's National Solar Mission was initiated in 2010 when the country's solar power capacity was minimal. It has been a transformative journey as India now has the fourth largest solar power capacity in the world, yet more needs to be done to encourage generation and use of solar power.

India's solar journey has been fascinating. When Prime Minister Manmohan Singh took the decision in 2009 that India should have a national solar mission, the solar power capacity in the country was barely a few hundred megawatts (MW). [The mission was launched in 2010](#) with the ambitious goal of creating 20,000 MW of solar power capacity by 2022. We now have more than 70,000 MW of solar power capacity and rank fourth in the world in terms of it.

This kind of success is rare for India. Analysing how this happened leads to interesting insights.

Prime Minister Indira Gandhi recognised the imperative of balancing the needs of development and preserving the environment. She created a new Department of Non-conventional Energy Sources in 1982, which has since grown into the [Ministry of New and Renewable Energy](#) (MNRE). The potential of solar power was recognised early on. A public sector company, CEL (Central Electronics Limited), took up the production of solar panels. These were installed in remote locations.

But solar power remained very expensive and the programme remained modest. The pro-market paradigm became dominant in the 1990s and the public sector across the board experienced neglect. CEL was no exception and it became gradually irrelevant.

As the challenge of global warming increased, India found itself subject to international pressures. One of our major diplomatic achievements in the early 1990s was the adoption of the principle of “common but differentiated responsibility” at the United Nations Conference on Environment and Development in Rio de Janeiro. But in the advanced economies there has been an appeal of the argument that whatever they did to lower carbon emissions would be more than offset by rising emissions from large developing countries such as China and India. The consequence has been continuing pressure on India to do more.

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There have been no takers in the West for the Indian view that our per capita emissions are low, that we need to focus on development, and that we will see to it that our per capita emissions will not exceed those of the advanced economies as they bring their per capita emissions down.. On the contrary, our total emissions, which are naturally large due to our large population, are made central to the narrative with the demand that we should assume greater responsibility. The tension between this stance and our unmet demand for climate justice, financial assistance, and technology transfer, has been a central feature of international negotiations on climate change.

Going solar

In view of the realities of the international balance of power and our need for Western goodwill and support, India has felt the need to act and demonstrate “good intentions and action”. This has been a factor in shaping policy. As early as around 2000, there was a proposal to enact a law mandating the share of renewables in our electricity generation. A group of ministers was set up to consider it.

When the huge difference between the price of electricity from renewables and from thermal plants as well as the existing financial stress of the state electricity boards were fully appreciated, the idea of having a separate law mandating a share of renewables was quietly dropped. A new [Electricity Act was enacted in 2003](#). The intention to promote renewables was clearly enunciated in it with the state electricity regulatory commissions being given the responsibility to determine the share of renewables for each state and to increase this share progressively.

In 2009, when Manmohan Singh announced the national solar mission and displayed responsible climate leadership, it was one of the unusual cases where the prime minister decided on his own, set a specific target, and asked his government to begin implementation.

Normally proposals would emerge, wend their way through the process of scrutiny by the Planning Commission and the finance ministry, and then a decision would be taken.

In this case, the enormity of the challenge was stark. The [Central Electricity Regulatory Commission \(CERC\)](#) had approved a tariff of around Rs 17 for a unit of solar power. The cost of electricity from a new thermal plant was about Rs 4 per unit. The implication was that a subsidy of Rs 13 per unit was needed to be able to sell this expensive power to state distribution companies. Both the Planning Commission and the finance ministry threw up their hands saying that there was no money for a subsidy bill of this order.

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An innovative way was found to begin implementation of the solar mission without taking any money from the government.

The pre-reform practice of the state-run power generator NTPC having thermal plant-wise tariffs on the basis of actual costs with a reasonable return on equity had survived. Each NTPC plant was a regional plant with 85% of its capacity allocated to states of the region on the basis of a formula. The remaining 15% was available to the central power ministry for allocation to states at its discretion. Electricity from the older plants where the capital cost had been amortised was quite cheap. By combining 4 units of such cheap power with 1 unit of very expensive solar power, the states were offered electricity at the same rate as that from a new thermal plant. They were willing to take this bundled power. The mission could thus take off without any budgetary support.

Two other unorthodox decisions were taken. The first was to invite repeated bids for the supply of solar power under long-term contracts with the price being the only selection criterion. Initially, the bids would be for small quantities. No government agency was tasked to put up solar power plants though this would have been in keeping with past practice. There were also voices in favour of implementation through private developers with cost plus tariffs as determined by the CERC to get speedy results. These views did not prevail as it was felt that competition would lead to lower prices.

The other was to try and create a competitive industry structure. This was attempted by initially inviting bids for small capacities to get more competition. It was decided not to give the entire quantity bid out to the lowest bidder as was the norm, but to also give smaller quantities to other bidders even if they were not able to match the price of the lowest bidder. However, the gap in prices was not to be too wide.

The results of the first round of bidding went far beyond optimistic expectations. The selected bids ranged from Rs 10.95 to Rs 12.24 whereas the CERC-determined price was around Rs 17 per unit. 150 MW of solar panel capacity was contracted. Many new firms entered the market. Quite a few have succeeded and are now large players.

The quantities bid out in subsequent years were increased gradually at first and then sharply. Prices kept falling. As the amount of discretionary NTPC power with the power ministry was limited, the government introduced a generation-based incentive scheme where the bid was for the subsidy needed per unit to provide electricity at Rs 4.50, the price at which the states were willing to buy solar power. The fall in bid prices continued and in a couple of years no subsidy was required.

Prices have continued to fall. India has the cheapest solar power rates in the world, around Rs. 2.50 a unit. Domestic competition has led to us having the lowest deployment costs.

But the real cause of solar power becoming so cheap has been the incredible success of China in lowering the costs of production. The Chinese dominate the global market. Our solar projects have been using panels imported from China.

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A key insight has been that if investment is de-risked through a long-term procurement contract, which gives returns with an implicit state guarantee, private investment is forthcoming even in new areas. At a micro level, financing for both debt and equity has not been a constraint, as returns on investment are adequate and risk mitigation has been put in place. Since India is well integrated into global financial markets, firms are able to access global capital of which there is an abundance. This is a useful lesson for the future in other sectors.

Next steps

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A beginning was made by notifying that in the first year the modules and in the next year, the cells and modules had to be made in India for the projects for which bids were to be invited. When this condition was made public, the US took strong objection, stating that this violated World Trade Organization (WTO) norms. What followed was illustrative of the contradictions and lack of cohesion such situations produce. The US took India to the WTO. India contested the case, but lost.

India could have used the duration of the case to implement the condition of modules and cells being made domestically for the next round of bidding. It did not. Nor did we try and persuade the US that all that they would achieve was to open the Indian market to the Chinese and get nothing except a victory over a principle.

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There was the simpler option of using the permissible route of government procurement where there is freedom to impose conditions of full domestic content and value addition. This recourse remains available. This may be better and more effective than imposing duties, or providing production-linked incentive benefits. But such procurement has to be along the lines of the solar bids, which means purchase of, say, 1 GW for five to seven years from the year when a new plant can go into production. Further, bids would need to be repeated so that a few competing firms emerge.

Power from large grid-connected solar projects need the creation of transmission lines whose capacity utilisation is necessarily lower as no solar power is generated at night. As an incentive for the nascent solar programme, transmission charges for solar power were waived and this cost was socialised by adding it to the transmission cost of other power. As the share of solar power was so minuscule, it hardly mattered.

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But as the costs of solar power have declined so much, the original rationale for the special dispensation of waiver of transmission charges has ceased to exist. The waiver, however, continues as an additional incentive for the use of solar power. This has been extended to green power for captive use including the production of green hydrogen.

Decentralised solar power generation at consumption points is cheaper as there are no transmission costs. In India, efforts at promoting rooftop solar have had relatively modest success in spite of generous subsidies. Only 11 GW of rooftop solar capacity out of a total of more than 70 GW of installed solar power that has been created so far. There could be a combination of factors behind this.

A programme supported by subsidies is inherently constrained by the subsidy allocation in the budget. Once the subsidy budget is exhausted, a potential beneficiary will have to wait for the next year. Then, the transaction costs of getting an individual subsidy acts as a deterrent. Further, the local distribution company (discom) has a rational incentive to try and impede progress. The discom loses revenue from its higher rate-paying cross-subsidising consumers. These are the ones usually putting up solar panels.

The [Kusum scheme aims to achieve the solarisation of irrigation](#) with the installation of solar panels and energy-efficient pumps. One third of the cost is a subsidy from the central government, another one third is from the state government, and the farmer has to provide the last one third, either on his own or by taking a loan. This programme has made modest progress.

Getting subsidies from two sources and finance from a third has large transaction costs built into the design of the programme. Farmers usually get free or practically free electricity for irrigation. There is therefore no incentive for them to go for solar panels and energy-efficient pumps. What would work would be the creation of an efficient implementation agency, which provides farmers with a bundle of services in finance, equipment supply, installation, and maintenance with a performance guarantee, and to have an attractive rate for selling solar power to their discom when it is not needed for irrigation. The farmer has to see financial gain to want to go in for solarisation.

Back of the envelope calculations suggest that there is a net life cycle financial gain if the solar panel and pump go to the farmer as a grant in lieu of free electricity. The implication of this is that with a net present value (NPV) saving, about 18% of India's present electricity consumption that goes for irrigation could become carbon free and at the same time result in life cycle savings for the government.

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One uniform attractive feed-in tariff for purchase of decentralised solar power in a state would be transformative. India has more than 600,000 villages and assuming a potential of just 1 MW in a village gives a potential of 600 GW of solar power. This would be financially beneficial to the discoms because the cost of purchasing decentralised solar power is lower than their actual cost of delivery to most villages in the country. Then there are the advantages of higher incomes for farmers and dispersed job creation.

The time for this now appears to have arrived with the prime minister's recent announcement of the PM Surya Ghar: Muft Bijli Yojana, a programme of providing rooftop solar panels to ten million households with the commitment to buy the excess solar power not consumed in a day. The prime minister has also said that these panels will be made in India. Government procurement on this scale will create domestic manufacturing capacity on the scale required for global competitiveness.

This announcement can be seen as a political response to the supply of free electricity in an increasing number of states by other political parties winning elections with this as a key electoral promise. With ten million households being given free solar panels, the political process is likely to lead to all households from the weaker sections being covered by this programme over time. The imbalance between large projects and decentralised small kilowatt-level solar installations would get rectified.

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Solar power rather than wind would have the larger share in our renewable energy programme. This creates the need for electricity storage to absorb generation when demand is inadequate. If the costs of storage become competitive, solar power with storage can meet additional demand without new thermal capacity. Fortunately, this is happening as seen from the price bids received and contracted by the [Solar Electricity Corporation of India \(SECI\)](#) in the last few years.

The mature technology of the last century, [hydro pump storage plants \(PSP\)](#), is now attracting private investment. Then there is the [concentrated solar power \(CSP\) technology](#) using molten salt for storing energy by concentrating the sun's rays at a point with large mirrors. The stored heat is used to run a conventional thermal turbine to generate electricity. The cost of such plants has come down and the SECI has announced its intention to invite bids for these. It has already awarded its first contract for battery storage.

Decarbonisation

Once the deployment of storage gathers momentum, there will be confidence that all additional demand can be met with reliability by renewables, primarily solar, with storage. Then there would be no need to build new thermal plants. This could happen sooner than expected. Our carbon emissions from electricity will peak without imposing any additional costs. At that stage, India could consider when and at what pace it would like to wind down its existing thermal power capacity.

The availability of land for solar power in the long run is a concern. The solar potential has been estimated at 748 GW by the National Institute of Solar Energy, though this may be considerably more on re-examination. But as we become a developed country in the coming decades, a five-fold increase in per capita generation could take place.

Fortunately, a transformational possibility is opening up with pilot agri-solar projects. Solar panels that can be rotated through remote sensors over crops would generate solar power in addition to improving crop yields. This needs detailed field trials in different agroclimatic regions. But in theory it can be the silver bullet for adapting to higher temperatures and preserving the food security we have. And all the cultivated area in the country can be used to generate solar power.

The solar journey has taken India much further than initially expected. Initial success would have made it easier for Prime Minister Narendra Modi to cooperate with the US to facilitate the landmark 2015 Paris Agreement on climate change. Greater success followed,

giving more confidence. The Prime Minister then announced in Glasgow at the 26th Conference of the Parties (COP26) in 2021 that **India would create 500 GW of fossil fuel-free capacity by 2030** and that the country would become net zero by 2070.

The creation of 500GW of non-fossil fuel capacity by 2030 is challenging but within reach. Solar power along with storage has made a carbon-free electricity system feasible. It is imperative that we succeed in making solar panels with full value addition and the equipment needed for all the storage options. In the medium term we should achieve self-reliance, energy security and lower costs. Carbon-free green electricity would also give us the green hydrogen required for decarbonisation of some of the hard to abate sectors. This would be the key to their decarbonisation. We could even try and reach net zero before 2070.