India's 100GW of Solar by 2022
Pragmatism or *Targetitis*?

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The Government of India's target of 100 gigawatts of solar power by 2022 reflects two perspectives. One, it embodies a practical need and urgency for solar energy from climate and energy security points of view. The other perspective, however, is that it shows the typical tendency of government authorities to draw up overly ambitious targets and be in a perennial promise mode. While examining the feasibility of this target, this article raises key concerns and offers suggestions on the appropriate land procurement and rooftop policies, as well as manufacturing strategies that need to be drawn up.

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The Narendra Modi government has set a target of 100 gigawatts (GW) of solar power capacity by 2022. Solar forms the largest component in the larger target of 175GW by 2022 for renewable energy-based power capacity, which also includes wind, biomass power, and small hydro. Once achieved, the share of renewable energy in electricity generation will increase to 18.9% from the current level of 7% (MNRE 2015a). An increase in renewable power capacity in general, and solar in particular, is certainly desirable for India. This can reduce dependence on fossil fuels and thereby improve energy and climate security. However, the question is whether the target of 100GW solar by 2022 is realistic or simply "a nice round" number. Has any feasibility study been done before setting the target, or is it an aspiration without basis? Do extra-ambitious targets enable the government of the day to remain in a perennial promise mode? Or are impossible targets the only way to discover the limits of the possible?

Let us consider this 100GW target for 2022 in perspective. The target has two parts: 60GW of utility scale projects and 40GW will be of rooftop solar. As per the Ministry of New and Renewable Energy (MNRE 2015b), as of 30 September 2015, India has a solar installed capacity of 4.3GW, of which utility scale solar contributed around 90%, the rest coming from rooftop solar.[1] As much as 99% of India's current solar capacity has been created in the last four and half years.[2] In 2014–15, there was a solar capacity addition of 1.1GW.[3] An achievement of 100GW by 2022 would require multiplying the current capacity by nearly 23-fold in the next 6.5 years. The 100GW target is five times more than the Jawaharlal Nehru National Solar Mission (JNNSM) target set in January 2010. The JNNSM had then set a target of 10GW solar capacity by the end of the Twelfth Five Year Plan, that is, 2017, and 20GW by the end of the next five-year plan, that is, 2022 (MNRE 2012).

A revision of the JNNSM target is welcome at this juncture given that the price of solar photovoltaic (PV) has dropped by 60% between 2010 and 2014.[4] The JNNSM target was originally based on an expected fall in solar production costs and achievement of grid parity by 2022 (MNRE 2010).[5] However, with the current trends in the fall of solar PV, grid parity is expected to be achieved by as soon as 2017 (MNRE 2012). But price is not the only challenge towards achieving the target of 100GW by 2022. There are issues relating to land, manufacturing, and technology, among others. This article will dwell on some of these aspects while examining the target.

Land Conundrum

Of the 100GW target, 60GW are to be ground-mounted medium- to large-scale solar power plants needing land.[6] Solar plants require as much land as conventional power plants. Mitavachan and Srinivasan (2012) showed that considering life cycle transformations,[7] a solar power plant requires land less than a hydro plant but of a similar level as a coal or nuclear plant. Assuming land requirement of five acres per megawatt (MW) (CERC 2015), the land needed for achieving the targets of utility scale solar is about 1,214 sq km. This amounts to as much as approximately 1.0% of the total culturable wasteland and 1.2% of the total fallow land of the country.[8]

The advantage of solar is that it does not transform or degrade the land as coal/uranium mining does nor does it cause submergence as dams do (Mitavachan and Srinivasan 2012). However, compulsory acquisition of large contiguous land tracts from hundreds of farmers for any mega project is a difficult proposition.

One alternative is to lease land from farmers instead of buying it so that the ownership remains with the farmers and they can benefit from the growing valuation of land over time. Leasing reduces the project cost and makes the affected farmers—as the Land Acquisition Act of 2013 proclaims in its preamble—"partners in development" in the truest sense. The Magarpatta special economic zone in Pune is an example of such a project in India. There are instances of some renewable energy projects in different parts of the world that have followed the route of leasing.

The second alternative, which seems the most farmer-friendly is "solar double cropping" or "solar sharing," that is, producing food and electricity simultaneously from the same piece of land. With spaced-out panels installed at a height, the land underneath can continue to be used for agriculture. This has been successfully demonstrated in Japan premised on the work of agricultural machinery engineer Akira Nagashima in 2004 (Movellan 2013). The electricity produced can directly be used for energising irrigation pumpsets and augmenting domestic supply to offset some of the severe load-shedding that takes place in rural areas. Also, a well-designed set of panels over the farmland can optimise photosynthesis by preventing sunburn of plants and by retaining moisture thereby reducing irrigation requirement (Ho 2013). Most importantly, under solar double cropping, the farmers continue to be in agriculture and retain land-ownership. They get additional benefits from electricity production by renting out the space above their land for such a purpose. The Gujarat Energy Research and Management Institute (GERMI) did a model for solar double cropping and asserted that this concept can be easily implemented in India (Harinarayana and Vasavi 2014). However, more studies and on-field experiments are needed to establish the impact on crops, the engineering of the frames carrying the panels and their cost, and the safety of farmers working below the panels.

Rooftop Solar

The grid-connected rooftop forms the second component of the 100GW target and has a 40GW share. With regulations (compulsory utilisation of rooftop space) and incentives (net metering and feed-in tariff), rooftops have good prospects for generating solar power.[9] Rooftop solar utilises unused rooftop spaces and the owners of such rooftops, as in the case of solar double cropping, can potentially either own the system or lease the space.

The policy towards rooftop solar needs to take into account two broad considerations. First, it needs to have an urban focus. Urban areas, compared to rural areas, enjoy a better ecosystem with concrete buildings, higher security, and greater availability of material and skilled human power (Nathan 2014). However, in the past the solar policy emphasis in India has been on meeting rural electricity needs. Several review studies indicate that solar systems have often failed in rural remote areas primarily because of maintenance issues at the locations due to a lack of infrastructure, supply chains, and human capacity.[10] Increased uptake of solar rooftops in the urban areas might naturally push the technology, like in the case of televisions or mobile phones, to rural areas, which can then take the advantage of scale (Nathan 2014).

The second consideration in rooftop policy is that among the urban buildings, institutional, industrial, and large commercial premises need to be given priority. The idea is to tap single consumers with large rooftop space and high electricity consumption. Government offices, educational institutes, hotels, factories, private firms, etc—particularly those which operate during the day and use diesel generators—are the lowest hanging fruits in this pursuit. Residential apartment buildings come down in the list of priorities as they provide common rooftop space with less area per consumer.

Between the options of utility scale and rooftop solar, the former has the advantage of being more cost effective (because of economies of scale associated with building and maintaining units of large size) and more efficient (because of optimal siting and use of mechanical systems to move panels to track the sun). However, rooftop solar is of a distributed nature and does not need additional land. Also, it does not require any power evacuation infrastructure and can work within the existing grid system.[11] Since rooftop systems are at the tail end of the grid, it reduces the overall burden on the grid and does not add stress to the transmission lines. Local generation and use of solar power minimises transmission and distribution losses. Given India's density of population and land constraints, rooftop solar is expected to play a prominent role (Philip 2014). However, the progress in rooftop solar has been relatively slow, and this is attributed to the lack of clear policies (Bridge to India 2015a; Jha 2015).

A Reality Check

One of the major challenges with ramping up solar in India is the limited manufacturing capacity available. Solar PV system has two broad elements—solar panels or modules (assembled from an array of solar cells), and the balance of the system (inverters, batteries, etc).[12] Solar manufacturing is an integrated process involving multiple stages. For instance, silicon-based PV technology has

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four sequential stages—silicon refining, wafer fabrication, cell production, and module assembly (Wolfe 2013). In India solar manufacturing is extremely fragmented lacking vertical integration; it is specifically sparse in the upstream of module assembly (Sharda 2015). As per the latest research by Green Tech Media, India has only 0.9GW and 2.1GW of cell and module manufacturing, respectively (Anand 2015). This is low given the yearly installation requirement of 13–14GW for the next seven years in order to reach 100GW by 2022.

India's National Manufacturing Policy (Ministry of Commerce and Industry 2011) had recognised solar as a sector of strategic significance. However, the solar manufacturing policy in India has not been effective enough. Forty percent of solar cell manufacturers have closed down and overall industry capacity utilisation is as low as 21% (Energetica India 2015). According to the MNRE (2014), in June 2014 the cell and module manufacturing capacity of the country was 1.22GW and 2.35GW, respectively, of which only 0.24GW and 0.66GW were operational. This situation is attributed to falling global prices coupled with the lack of cost competitiveness of Indian solar industry arising out of relatively insufficient government support, the smaller size plants, and limited access to raw materials (Energetica India 2015).[13] The latest data indicate that in 2014, India imported 74% of the modules and until August 2015 the corresponding figure was 78% (Bridge to India 2015c).

Compared to the global leaders in solar like Germany, the US and China, solar industry in India is new and the related technology development is low (Dutta 2012; Sharda 2015). India can potentially innovate and leapfrog into next generation of cell technology and improve efficiency in balance of system (ORF 2015). However, innovations ecosystem needs consistent support. In the last four years, the reports on global trend in renewable energy investments indicate that India's research and development stands at $0.6 billion, which is 14 times less than that of the US or China, and 23 times less than that of Europe (UNEP 2012–2015). In the same time period research and development as a share of new investments in renewable sector is 1.7% in India; the corresponding figures for China, Europe, and the US are 3.1%, 4.1% and 5.0%, respectively (UNEP 2012–15). Moreover, unlike the global leaders in solar, India does not have a culture of strong industry–academia research collaborations. The National Centre for Photovoltaic Research and Education housed at the Indian Institute of Technology (IIT) Bombay and the ONGC Energy Centre's pan-IIT collaborations (ORF 2015) are rare examples, given the size of innovation need in the country.

India has less leeway in cell and module manufacturing in the near future as the global market is dominated by a very few big players. It has a better level playing field in module assembly and manufacturing of the balance of the system (ORF 2015). A Global Technology Watch Group study by the National Institute of Advanced Studies in collaboration with DCCC, GERMI, and IIT Delhi suggests that to accelerate learning and innovation India can follow both the Chinese model of allowing manufacturing by

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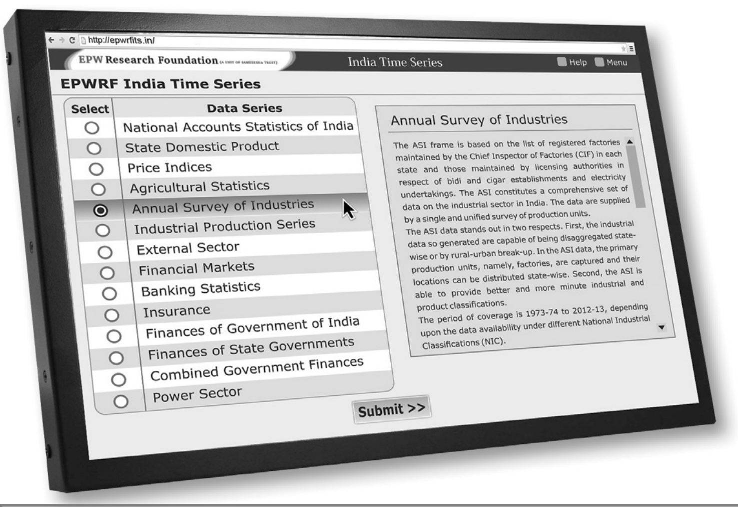

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C-212, Akurli Industrial Estate, Akurli Road, Kandivli (E), Mumbai - 400101 | Tel: 022-2885 4995/96 | Email: its@epwrf.in | Web: www.epwrf.in foreign companies and the US model of international partnership projects (NIAS 2015). The ORF (2015) report on R&D and local manufacturing in solar PV emphasises the German strategy of quality in niche areas to export to the other developing countries of the South. The non-manufacturing sector (installation, system integration, and operation and maintenance) in solar PV is of prime importance in the Indian context as it will be instrumental in job creation in the long run.

India has moved in the right direction in terms of initiating certain policy instruments, including providing accelerated depreciation, local content requirement, renewable purchase obligations, renewable generation obligations, bundling of conventional and renewable electricity, etc. But certainly to achieve installed capacity of 100GW in seven years, there are other challenges to overcome such as financing, offtake of power, storage, and grid-management.

Price of Over-targeting

An extra-ambitious target has its positives. It creates an upsurge in the mood in the sector. It triggers policies and investments. At times, it makes a society aim to achieve a seemingly unachievable goal. However, the flipside of extra-ambitious targets outweighs the merits. Over-targeting often leads to under-delivery. The *India Solar Handbook* (Bridge to India 2015a) puts achievable rooftop solar to be only 4GW by 2019. This is one-fourth of the government's expectation by the same year (MNRE 2015c), that is, we will fail by 75%. Such failures undermine the credibility of the authorities responsible for achieving the targets. People develop a sense of apathy towards the government in general and such targets in particular. The experience with universal electricity access is a case in point. The current government has postponed the universal electricity access target to 2019, but made it extremely ambitious with the promise of providing 24×7 electricity to all households (Josey and Sreekumar 2015). This is another target which India is going to miss most miserably in the future.

Nuclear power, among all energy sectors, has a history of making huge promises. The Atomic Energy Commission (AEC) in 1954 predicted that India would achieve a target of 8GW of nuclear power installation capacity by 1980 (Kapur 2006). The actual achievement in 1980 was only 0.6GW (Evans and Hope 1984). In 1962 there was a prediction of 20–25GW nuclear by 1987 and in 1969 the target was replaced with 43.5GW of nuclear power by 2000 (Ilina et al 2008). However, the fact of the matter is today with a fully operational unit at Kudankulam, India has achieved a total capacity of only 5.3GW of nuclear power (World Nuclear Association 2015), which is less than two-thirds of the 1980 achievement target. However, the Government of India continues to have these optimistic projections for nuclear power. The AEC has an ambitious target of 470GW installed nuclear power by 2050 (Mishra 2013).

Conclusions

The solar sector must not become the victim of this disease of *targetitis*. This sector has been known for its realistic goals. The JNNSM target for Phase I (2010–2013) was 1.1GW of solar grid power, 200MW of solar off-grid applications, and 7 million sq metre of solar thermal collectors (MNRE 2012). The actual achievements in the same time period either were met or exceeded the target: 1.7GW of solar grid power, 252 MW of off-grid applications, and 7.01 million sq metre of solar thermal collectors (MNRE 2015d). It is wiser to make moderately ambitious targets and achieve them. By doing this consistently, government departments can win back the confidence of industries and larger public.

NOTES

1 The share of utility scales solar in India's solar capacity as of May 2015 is 92% (Bridge to India 2015a). If one considers the recent data of Bridge to India (2015b, 2015c), the share of utility scale solar turns out to be 90%.

2 India's solar installed capacity was at 35.15 MW by 31 March 2011 (MOSPI 2015).

3 This is as per MNRE official figures widely reported by different agencies including Intersolar (2015) and *Smart Energy* (2015).

4 The price of solar power in India fell from Rs 17 per unit to Rs 6.5–7 in three years (Jai 2014). The most recent price for grid-connected large solar plants has fallen below Rs 5 per unit (Sharma 2015). Worldwide, the solar PV power cost halved between 2010 and 2014 (IRENA 2015).

5 Grid parity is a situation where the cost of electricity from an alternative source becomes equal or less than the prevailing price of grid-electricity.

6 There are two broad technology options for grounded solar, solar thermal power (this works on the same principle as conventional coal thermal with the difference that solar energy is used instead of coal to heat the water to convert it to steam) and solar PV. However, we have not discussed the solar thermal option here as it has not been taking off in India and has lost out the race against solar PV because of high capital and operating expenditure (more than twice as much as PV), less developed technology, a higher gestation period, greater land requirement, and absence of any successful demonstration.

7 Life-cycle land transformations include all the area that goes into setting up a power plant, fuel mining (coal and nuclear), transportation (coal only) and waste disposal (nuclear only) across the lifetime of the power plant.

8 As per the latest data on pattern of land utilisation, India's culturable wasteland and fallow land (excluding current fallow) amount to 1,28,570 sq km and 1,04,840 sq km, respectively (MOSPI 2015). The data corresponds to year 2008–09.

9 Net metering refers to one bidirectional meter, whereas feed-in tariff requires two meters to record inflow and outflow separately. Feed-in tariffs enables different pricing for electricity generation and consumption.

10 For detail reference on such studies, see Nathan (2014).

11 The additional infrastructure in case of utility solar is not fully utilisable given the low capacity utilisation factor of solar plants.

12 The solar cell is the basic element in PV system which converts solar energy to electrical energy. Balance of system refers to all components of PV system other than panels.

13 Support of the government to solar manufacturing has been relatively less compared to other solar leading countries of the world in terms of loans, tax concessions, and other subsidies (Energetica India 2015). Indian factories are on an average five times smaller than a typical Asian factory, and there is no domestic access to wafers and polysilicon (Energetica India 2015).

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