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RAHUL TONGIA

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No. 6, Second Floor, Dr. Jose P Rizal Marg
Chanakyapuri, New Delhi - 110021
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India's Updated (2016) Renewable Energy "Guidelines": Bold targets, but can we meet them?

Rahul Tongia
Fellow, Brookings India

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Key points

1) The Government of India has issued new norms for Renewable Energy (RE) in India, via guidelines for states to buy RE, through updated renewable purchase obligations (RPOs). These are central government guidelines, but ultimately RPOs will have to come from State Electricity Regulatory Commissions (SERCs). Historically, states have had weaker RPOs, and limited enforcement or penalties for not meeting targets.

2) The RPO guidelines are ambitious, and risk not being achieved. On the other hand, if one uses 175 GW of RE capacity by 2021-22 as a baseline, the RPO purchase guidelines could even *overshoot* the requirements, depending on growth of overall demand.

3) The RPO guidelines calculate share of solar in supply on the basis of generation excluding hydro. This adds a new factor for calculation, as well as unnecessary uncertainty.

4) The RPO guidelines break out solar versus non-solar in a manner that doesn't match the 100 GW solar out of the 175 GW total RE targets. (Solar is meant to be 8 per cent of generation, excluding hydro, by 2022.)

5) The growth of solar (and overall RE) has a discontinuity in terms of required capacity growth, with much more growth required in the coming few years than the final three years. It is not clear if this is optimal.

6) The most important factor for balanced RE is keeping it within the portfolio of supply options that meet overall demand. Any RE (or other power) above the optimal share will negatively impact the share of other generation, not necessarily cost-effectively. Coal is the mainstay of power in India, and it has seen falling utilisation in recent years. This is poised to become more pronounced if RE grows as targeted.

7) India's RE targets for 2022 imply a capacity growth rate of roughly 25 per cent per annum. In contrast, much-heralded plans like by California for 50 per cent by 2030 only require an annual growth of share of about 4 per cent per annum. Even compared with the EU or China, India's targets require a much higher growth rate.

8) India's ambitious RE targets aren't actually required to meet the INDC targets, since carbon intensity can likely be met via various other means.

GUIDELINES	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
Non-solar	8.75%	9.50%	10.25%	N.A.	N.A.	*11% (?)*
Solar	2.75%	4.75%	6.75%	N.A.	N.A.	8%
Total	11.50%	14.25%	17.00%	N.A.	N.A.	*19% (?)*

Table 1: RE Purchase Obligations (proposed - 2016). The cabinet-approved amendments to the National Tariff Policy ask for a solar RPO of 8 percent, excluding hydro, by 2022, while the coming three years' targets are based on a Ministry of Power Order 23/3/2016 R&R. Only the portions boxed in red are declared.

Background for RE and purchase obligations in India

The government has announced a number of targets and support mechanisms for RE. Almost two years ago, the central government announced plans to grow to 175 GW of RE capacity by 2022, more than a five-fold growth in just seven years. RE has since been supported through a number of financial and non-financial means (and enjoyed support even before the 175 GW targets). Recently, the Indian cabinet approved amendments to the National Tariff Policy to push for 8 per cent of generation to come from solar by 2022 (excluding hydropower). The approval also talks of free inter-state transmission of wind and solar. On the other hand, the same amendments ask for maximising use of existing power plants to save money. At some point, maybe sooner than people realise, this will lead to a disconnect.

While RE is worthy of support, one has to triangulate its implications, not just on the grid or finances, but also on alternative sources of supply as well. To scale sustainably, RE needs not just improvements in costs (solar prices are falling the fastest of major RE sources) but also improved frameworks for incorporating such power to the Indian grid. As a Brookings India study has shown for RE, coal, and power demand, if we try and triangulate, the numbers don't quite add up. The targeted 1,500 million tonnes of coal (by 2020)—mostly used by the power sector—and an added 175 GW of RE by 2022 would lead to an overcapacity of supply.

Mandates are one of the most direct forms of achieving targets. While the focus of this paper is not to examine the economic viability of RE or the targets, this paper does examine India's RE plans through several comparisons:

1) Compare the capacity targets with the generation (consumption) targets
2) Examine the RE growth rates required
3) Compare India's RE targets with targets elsewhere

RE has needed (and still enjoys) support

If one only uses price as a metric, the calculus is easy: once "cheap enough" everyone will love renewables. The fact that we have support for RE, ranging from free transmission to tax breaks and explicit subsidies in many cases, suggests that RE requires subsidies, de-facto subsidies, or other support. Even the proposed amendments to the Electricity Act 2003 enshrine such support for RE, especially through waivers of certain costs like transmission charges or Open Access surcharges.

In addition to the cabinet approval for 2022 solar targets, the Ministry of Power released annual RE purchase guidelines for the coming three years, for both solar and non-solar RE. RE in India is defined as per the Ministry of New and Renewable Energy (MNRE), and unlike many other countries, India excludes hydropower above a size threshold from RE calculations, dubbing it conventional power. Thus, India is far more "green" than many people realise.

Understanding the RPO numbers - Too little or too much?

Renewable Energy is a capital-intensive source of generation where the costs are mostly up-front, with little operating costs and no fuel costs. The output typically varies over time due to the vagaries or realities of nature and the capacity utilisation factor (or Plant Load Factor, PLF) is much lower than that of traditional thermal power plants, which can operate at 80 per cent. However, recent thermal power plant PLFs have fallen due to over-supply and relatively muted demand. RE, especially wind and solar, typically operates at about 20 per cent PLF, if not lower, depending on the location.

The 175 GW RE target of some two years ago was bold, announced well before any explicit carbon considerations as volunteered for COP21, but there was limited clarity on the details, challenges, or means of getting there. It was only later that there was a tentative breakdown of state-wise targets. It's illustrative to see that the RE targets continue to have a skew across states. While some of the RE pioneers like Tamil Nadu, Maharashtra and Gujarat have among the higher targets, many of the states that currently have a low RE base also have high targets, such as Uttar Pradesh with a solar target of 10,697 MW.

A lot of the effort of stakeholders went towards finance, mirrored by global trends finding RE power investments to be the majority of capacity focus (more than fossil-fuels in 2015). From a usage point of view, the general expectation remains that RE is "use it or lose it", and so the PLF would be approximately 19 per cent plus-or-minus. Thus, the 175 GW capacity target would have a more modest impact on the share of RE by generation.

How does one translate a capacity target to generation norms? Popular across the world are Renewable Purchase Obligations, also termed Renewable Portfolio Obligations. The mild RPO targets seen in Indian states in recent years were just upended by central government guidelines that are multiple times higher (Table 1).

Importantly, there is a recognition that these can only be guidelines, since State Electricity Regulatory Commissions have to declare the official RPOs for the utilities.

Analysing the RPO guidelines in some more detail, we find:

1) *Confusion and inherent uncertainty due to excluding hydro from the base of total generation*
While traditional hydropower is not part of RE, for the solar obligation states 8 per cent of generation excluding hydro. There isn't clarity on why this was chosen. Removing hydro from the denominator (the basis for calculating share of solar) to reach 8 per cent is a first.

    This makes calculations difficult since hydro PLFs vary measurably depending on the monsoon, while solar output is relatively predictable. Let's assume hydro output fell dramatically in one year (a few per cent in absolute terms of total generation, which has happened before). This doesn't impact solar's share of *total* output much since RE is assumed to be supply limited (use it or lose it), but it does change the share of solar excluding hydro. This is because the alternative basis for calculation (total consumption or supply) would remain relatively constant, and any the shortfall of hydro would be met by other generation.

    In addition to uncertainty, this also changes the effective numbers when we try and calculate share of solar (or RE) out of total supply. If we estimate a share and output (PLF) of hydro, we would find that we might have on the order of 10 per cent from hydro in 2022 (detailed estimates come a little closer to 11 per cent of total generation). It would be better to declare a solar target as 7 per cent overall instead of 8 per cent excluding hydro (or whatever detailed projections call for with hydro removed).

2) *Inconsistency in share of solar vs non-solar RE for the targets*
   Before we can compare solar vs. non-solar RE, we have to know non-solar RE targets. These aren't declared for 2021-22.

   Non-solar today is much higher than solar RE in capacity, so the expected growth rate to meet the targets is much higher for solar. Over the three-year period from 2018-19 to 2021-22, there is a reduced *rate* of growth for solar, to go from 6.75 per cent to 8 per cent, which suggests there would be something similar for non-solar RE. In fact, as Table 4 shows, even the absolute growth of required capacity comes down in the latter three-year period. While not declared, we have estimated a similar (slower) growth to come up with a low-end target of non-solar RE as 11 per cent, making overall RE's share at 19 per cent (Table 1).

   Given that solar comprises 100 GW of the 175 GW total RE target by 2022, if one were to be proportional, the corresponding non-solar RE would only need to be 6 per cent, which is close to being met today itself. This is assuming similar PLFs – in reality biomass and small hydro can have a PLF higher than 19 per cent. Even for wind the PLF is similar only on average—PLFs for higher hub heights in good locations can be measurably higher.

   This means that either the total RPO (solar plus non-solar) is met by 2022 with a different split between solar and non-solar *or* if the solar RPO of 8 per cent is met, then the targets for non-solar are too high (at least compared to the 6 per cent required non-solar vis-à-vis solar of 8 per cent). Correcting for the hydro in the denominator (assuming a comparable base), the net non-solar RE requirement would only be 5.25 per cent of total generation, something that is already being achieved!

   All of this can be normalised by using 175 GW in 2022 as the basis. If 100 GW is to be solar, and 75 GW non-solar, this suggests that whatever total RPO we choose should have one-third more solar than non-solar RE. This isn't the case, even with the limited information available. If we have 8 per cent as the solar RPO, and 6 per cent for non-solar, plus removing hydro from the basis, this may be too low compared to the 175 GW target.

3) *Lack of clarity on which has primacy: capacity or generation? There are also temporal issues comparing the two (one is a snapshot, while another is cumulative).*
   The share of generation from RE links to capacity through the PLF. While RE might ostensibly have a PLF of 19 per cent (the figure used by MNRE in their calculations), comparing a snapshot capacity with annual generation will not add up since capacity is end-of-year (March 31), while generation is cumulative over the year. Given that capacity is monotonically increasing, multiplying it by 19 per cent PLF to calculate expected output would overstate the expected generation in billion units (kWh), also termed BU. Correcting for a high growth rate implies that the corresponding expected or usable PLF would need to be 18 per cent, if not lower (more so for higher growth rates).

   This is a challenge common to all PLF or share calculations where the capacity is growing rapidly. Hence, an 8 per cent solar target needs to be clarified whether it is prospective or historical? One possible calculation is to consider generation (and capacity) on a monthly basis, and compare these. One significant problem is seasonality, more so for wind but even for solar. Hence, an annual number makes the most sense, but itself would display year-to-year variance. For our calculations, we simply adjust from nameplate PLFs to annualised PLFs (such as with an estimate of 18 per cent effective PLF instead of the nameplate 19 per cent PLF).

One always has to choose a base or starting point: capacity or generation. Capacity is much easier to measure and plan for, but share RE generation can be better from a system perspective (and is more common worldwide). That is because share RE involves not just requisite addition of RE capacity but also the denominator, i.e., the overall generation. What if growth of power demand turns out lower than originally planned? One can still meet the RPO generation targets with a lower RE capacity.

This is a non-trivial issue for India, since demand growth has varied significantly over time (and is linked to GDP growth, which itself varies). The Central Electricity Authority (CEA) is undertaking analysis for the 19th Electric Power Survey (EPS). Preliminary results based on state-wise energy requirements by the year 2022 suggest that the assessment of energy requirement by the 2022 made in the earlier 18th EPS (which came to 1,900 BU) would need to be scaled down significantly. In fact, their estimates for demand are now 20 per cent lower, and yet lower if we remove hydro generation. If we take 175 GW as the base, this implies that the share of RE from such a capacity could become higher than 20 per cent, even with an effective PLF of 18 per cent. We examine this further in Table 2.

4) *Lack of visibility and clarity on types of solar generation (rooftop vs. utility-scale)*
The generation from solar is listed for the total output (excluding hydro) at 8 per cent, but the 100 GW of solar capacity target actually includes 60 GW of grid-scale and 40 GW of rooftop solar. For simplicity, one could consider "rooftop" to cover warehouses, backyards, etc., anything "behind the meter" of a consumer, but this isn't standardised. As we have capacity targets of 60:40 for grid-scale and rooftop solar, the generation would be mostly similar (grid scale usually has slightly higher generation).

It would be important to first begin tracking grid-scale and rooftop separately in (near) real-time. The latter is very hard to track because of its diffuse nature. Grid-scale is easier for the central government not just to monitor but also support, such as through free inter-state transmission or massive solar parks where a lot of the infrastructure is already taken care of. In contrast, data of generation by end-users is very hard to gather, especially if this is self-consumed under net-metering schemes.

One major study by a coalition of stakeholders (disclaimer: I was a reviewer and coalition partner) estimated that current policies would only get us to roughly one-third of rooftop solar targets. Increasing market support could double growth to two-third, but to reach 40 GW would require new and focused policies and actions. This doesn't necessarily mean a high feed-in-tariff; utilities strongly resist such efforts, especially after initial support which could be pushed top-down.

In India, like most other countries, roof-top solar will be measurably more expensive than grid-scale solar due to higher costs of capital and economies of scale, scope, and volume. This is compounded by the fact that only Commercial and Industrial (C&I) consumers have high electricity prices (along with the highest tier—a small minority—of households). This means rooftop solar will come from the so-called paying (rather, over-paying, or cross-subsidising) consumers. This creates barriers for utility- and state-level support for feed-in schemas, who worry about negative revenue implications. In contrast, in the West, residential consumers pay the highest for their electricity, reflecting higher costs to serve (on average). Europe had to scale back feed-in tariffs for solar due to the costs involved, leading to reductions in investments, highlighting the limits of subsidy or cross-subsidy mechanisms to grow RE.

5) *Uncertainty over too little vs. too much*
How do the total RPO targets compare? Assuming "excluding hydro" also applies to the denominator of non-solar, the grand total of perhaps 19 per cent RE (excluding hydro) comes to a corrected (adjusted) RE of approximately 17 per cent on total generation. (In case "excluding hydro" doesn't apply to non-solar, then the total RE target would be around 18 per cent.)

Power Demand Growth Rate	BU power demand in 2022	Generation [BU] from 175 GW RE (@18% PLF)	RE share (of total generation)	Power demand [BU] less hydro (est. @ 10%)	Share RE of adjusted generation (excl. hydro) with 175 GW RE
6%	1,576	275.9	17.5%	1,419	19.4%
6.5%	1,629	275.9	16.9%	1,466	18.8%
7%	1,684	275.9	16.4%	1,515	18.2%
7.5%	1,739	275.9	15.9%	1,565	17.6%
8%	1,797	275.9	15.4%	1,617	17.1%

Table 2: RE Generation Share from 175 GW Capacity for varying total demand in 2021-2022.

If we compare the generation likely from 175 GW of RE at the rate of 18 per cent effective PLF (which comes to 275.9 BU over the year), depending on the total power demand, this can mean we only need a total RE share of between 15.4 per cent and 17.5 per cent RE overall, or 17.1-19.4 per cent excluding hydro. We see that the declared guidelines could overshoot the required RE share, more so if the total demand for power is high. It is entirely unclear how power demand might materialise in the coming years.

Ambitious RE and RPO targets

There is a very thin line between ambitious, which pushes the envelope, and unachievable or distortionary. It is clear that RE, while growing, needed a push and support to grow further. Renewable Energy Certificates (RECs) have stabilised at low prices and low volumes, and states faced minimal, if any, penalties for not meeting the older RPO obligations.

The catch is if the mandate is too far beyond economic viability, this becomes an *unfunded mandate*. This then means making economic choices or tradeoffs. Money is always either limited or at least fungible, i.e., spent better elsewhere. If carbon was the concern, there are a number of cases where energy efficiency is a far superior option to supply-side options such as "green power". It is beyond the scope of this paper to examine economic viability. However, we can study "ambitious" in the context of growth rates and other countries.

Growth Rates Analysed

Using 2014-15 as a base (the period for the 175 GW targets announced), we can estimate the corresponding RE growth rates for achieving the targets (Table 3). We chose 175 GW of capacity as the basis, instead of consumption, since consumption share also depends on assumptions on growth of demand and alternative sources of power.

		Total Power Demand	Capacity RE	RE Generation @18% PLF	Share RE Generation (incl. hydro)
(units)		BU	GW	BU	%
		[a]	[b]	[c]	[d]
Base	2014-15	1,048	35.8	61.8	5.89%
Target	2021-22	1,739	175	275.9	15.9%
Calculated or assumed	CAGR	7.5% (assumed)	25.5%	23.8%	15.2%
Projected for smooth target	2014-15	1,048.4	35.8	61.8	5.9%
	2015-16	1,127.0	44.9	76.5	6.8%
	2016-17	1,211.6	56.3	94.7	7.8%
	2017-18	1,302.4	70.6	117.3	9.0%
	2018-19	1,400.1	88.6	145.3	10.4%
	2019-20	1,505.1	111.2	179.9	12.0%
	2020-21	1,618.0	139.5	222.8	13.8%
	2021-22	1,739.3	175.0	275.9	15.9%
(for reference)	2015-16 actual	1,107.4	42.8	65.8	5.94%

Table 3: Projected RE capacity and corresponding generation for meeting 175 GW RE capacity by 2022. Initial data (2014-15) are from CEA. The first segment calculates the compounded annual growth rates (CAGRs) for both power demand and RE based on 2022 targets, and assumes a base 7.5 percent growth of power demand. Using the calculated CAGRs, we project annual power demand [a], capacity RE [b], RE generation [c], and share RE generation [d], assuming a smooth progression of RE capacity. The actual RE targets are not geometric, with higher growth in earlier years (on a lower base). For illustration, we can compare projected with the actual 2015-16 numbers. Note, the CAGRs for columns [b] and [c] aren't identical since the base year generation share doesn't align to the 18 percent effective RE PLF (see the above section for an explanation of effective PLF).

We can see that to reach the capacity target of 175 GW RE, we would need a compounded annual growth rate (CAGR) of RE capacity of 25.5 per cent, a heroic task. This would increase the overall share of RE generation (on a base including hydro) to just under 16 per cent, based on the effective PLF of 18 per cent and a healthy demand growth of 7.5 per cent.

The above Table 3 shows a smooth progression for illustration purposes only, which may not mirror reality or even the targets. The reported total RE targets for 2015-16 were only 4.46 GW, while the MNRE targets for just wind and solar (the bulk but not all of RE targets) for 2016-17 are 4 GW and 12 GW, respectively. Any deviations from either benchmark isn't an issue since progress is unlikely to be smooth. One could argue that future growth will be higher than near-term growth as the costs of RE are falling continuously. However, the flip side of such skewed growth is that grid integration and management is disproportionally harder.

Table 3 assumed a 7.5 per cent growth rate for power demand, while Table 2 showed the shares with different growth rates of power demand. What will the future hold? Even projecting to 2022 is difficult, forget 2030 (the year for India's INDC carbon pledges). Most recently, we have seen a dip in GDP to power elasticity, in part due to the rise of services, and in part due to improved energy efficiency. Even a 0.9 elasticity and 8 per cent GDP growth only means a 7.2 per cent growth of power. Adding in 100 per cent electrification and zero load-shedding comfortably leaves 7.5 per cent as a fair base calculation. As CEA has projected, it's possible that the demand growth may be lower.

While high growth *rates* for RE are much easier on a low base, how do the numbers look when we examine required *capacity* requirements? For calculation purposes, we now treat RPO as the basis, to calculate corresponding solar capacity over time. Using the solar RPOs as declared in Table 1, we find both a huge requirement of capacity increase, as well as a substantial slow-down in growth requirements towards the tail end of the period (Table 4). This slow-down is substantial, with an annual average of only 8.5 GW solar required over the last three years, compared to 12 GW in the ongoing year (2016-17).

Sensitivity analysis for the demand of power (critical for an RPO based on share of consumption) shows that if the power demand grows by less than 7.5 per cent CAGR, then the required solar growth would slow down, relatively affecting 2021-22 requirements far more than the 2016-17 growth requirements. This further reduces the final three years' average solar capacity growth requirement to as low as 7.5 GW for 6.5 per cent growth of power demand.

	Solar Guidelines for generation (excl. hydro)	Generation based on 7.5% growth, excl. hydro @10%	Corresponding Solar generation	Solar capacity reqd. @18% effective PLF	Annual solar capacity growth reqd. for Targets with 7.5% generation growth	{Sensitivity} Annual solar capacity growth reqd. for 7% generation growth	{Sensitivity} Annual Solar capacity growth reqd. for 6.5% generation growth
(Units)	%	BU	BU	GW	GW	GW	GW
	[a]	[b]	[c]	[d]	[e]	[f]	[g]
2014-15 Actual		944					
2015-16 Actual		1,014		6.763	3.019		
2016-17 Target	2.75%	1,090	30.0	19.0	12.3	12.1	11.9
2017-18 Target	4.75%	1,172	55.7	35.3	16.3	16.0	15.7
2018-18 Target	6.75%	1,260	85.1	53.9	18.6	18.1	17.6
		1,355		-			
		1,456		-	-	-	-
Target 2021-22* ***(3 years gap for RPO)***	8.00%	1,565	125.2	79.4	25.4* (8.49 for 3 years annual avg.)	23.9* (7.98 for 3 years annual avg.)	22.4* (7.48 for 3 years annual avg.)

Table 4: Solar RPO's corresponding capacity increases required. All calculations for Target assume that generation [b] is per a smooth growth of demand at 7.5 per cent based on 2014-15 (and 7 per cent, 6.5 per cent for sensitivity in columns [f] and [g], respectively). Hydro is assumed as 10 per cent throughout, even though actual data are available for the "Actual" years. Effective PLF is lower than nameplate for reasons described before. Note that the last row with 8 per cent solar target (excluding hydro) is after a three-year gap in available numbers. Thus, the large requirements in solar capacity growth [e through f], boxed to highlight the key calculations] are over three years, and simple annual average is also shown.

Source: Generation data as per CE, actual capacity and growth data as per MNRE website.

Such a dip in future years' RPO to capacity for overall RE is likely to take a similar trend, but we don't have an explicit non-solar RPO notified for 2021-22. This trajectory for the RPO (solar and overall), highlighted in Figure 1, requires greater multi-stakeholder discussion.

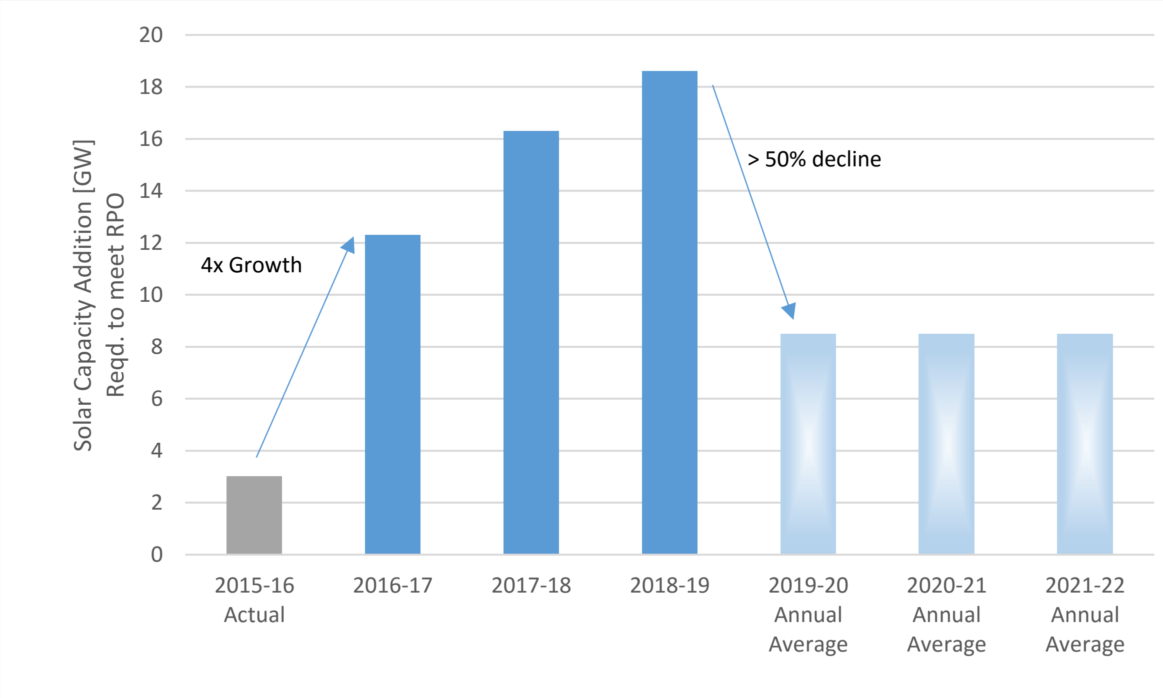

Figure 1: Growth of solar capacity required per year to meet solar RPO. This assumes overall growth and other details as per Table 4.

Are the targets chosen because one could assume there is latent demand or at least ability to absorb limited RE by the states, after which some level of saturation kicks in? Several counters to this view would be:

- Growth rates that are relatively steady on a normalized basis are far easier than increases that are step function increases (e.g., a four-time increase in capacity growth required year-over-year between 2015-16 actual and 2016-17 targeted). Normalised growth (percentage based) is often a good indicator of growth levels that are achievable and sustainable.
- In the future, costs of solar (and other RE) are only expected to fall further, making economic viability much easier in the future. In addition, one would expect some level of grid strengthening by then. It's important to note that niche transmission is a major requirement for concentrated RE, and the timelines to add major transmission (several years) is multiple times longer than the timelines to add corresponding RE capacity.
- A decrease in *absolute* solar (or any power) capacity growth requirements is problematic for industry that builds up manufacturing capacity over time.

Some comparisons for RPOs

Long-term RPOs are feasible and less disruptive as they allow graceful changeover to RE, with older plants retiring or being paid off. California has recently legislated a very aggressive RE share of 50 per cent of retail consumption by 2030 (upgrading the earlier target of 33 per cent). While this looks exceptionally impressive as a fraction of RE compared to India's numbers in Table 3, there are several considerations.

Hydro is also mostly excluded in California from qualifying as RE but the threshold for inclusion is up to 30 MW, a bit higher than MNRE's 25 MW. Land is a major difference: California has a large coastline, reasonable sunshine, and a 2010 population density of 97 persons/sq. km, compared with India's 382 persons/sq. km in 2011. Even today, the state is a pioneer, and its present RE share of over 25 per cent is much higher than the national average. Even within India, the "best" state might similarly achieve an almost double RE share compared with the national average.

More importantly, what is the growth rate for this? California has reportedly achieved 30 per cent of power from RE, and so growing to 50 per cent over 14 years (by 2030) is only a CAGR of 3.7 per cent. Since that is an unofficial estimate of the current status, using 2014 official numbers (16 years to 2030), the required growth would only be 4.4 per cent CAGR. This is much, much lower than the 25.5 per cent growth in RE capacity required for India (column b of Table 3), that too, over a much, much shorter timeframe. Of course, there are a few issues which make California-India comparisons difficult, such as the difference between generation and retail consumption.

Here, we acknowledge limited growth of power demand in California (in fact, falling over the last decade, which makes the share of RE targets easier in terms of new capacity growth requirements), and also its modest GDP growth rate. Even with such limited growth of power demand, the RE change rate is approaching the retirement rate for older plants (a 30-year lifespan implies a 3.33 per cent annual retirement rate). While India has a high growth of power demand (perhaps 7-8 per cent per annum), there is disproportional investment required to meet demand from RE due to its low PLF—much more capacity is needed. The jury is also still out whether this much RE growth (25 per cent) can be absorbed by the system without substantial effort and investment. This is before considering ability to pay: in California the average retail cost of electricity is roughly Rs. 10/kWh (taken from 2015 and 2016 EIA data), and the residential rate is substantially higher than the average, the opposite of the case in India.

The European Union also has ambitious RE targets, dubbed the 20-20-20 targets. This target, for energy instead of electricity, was crafted in 2007, and legislated just over a year later, allowing 12 years to reach the targets. These ask for a 20 per cent reduction in CO2 (using 1990 as a base), 20 per cent reduction in energy use via efficiency, and 20 per cent share of energy from renewables. Given that in the EU the 2010 share of RE was 9.8 per cent, doing a simple calculation one finds that to double to 20 per cent by 2020 requires a CAGR of 7.4 per cent for share of RE (by generation). Given that the targets also ask for a reduction of energy use by 20 per cent, and assuming little or no retirement of existing RE capacity, this means the CAGR for RE to meet the usage share targets would fall to roughly 5 per cent.

The EU's achievements for RE-based electricity are impressive, but still show a much more modest growth rate than India is targeting. From a 2004 base of 14.4 per cent RE in terms of gross electricity generation, Europe's RE has grown to 27.5 per cent in 2014. However, comparisons are not direct as Europe includes hydropower in RE calculations, and hydro was 43.9 per cent of the total RE electricity generation in 2014. In addition, like California, European electricity prices are much higher than India's average prices, increasing bottom-up demand for RE power.

If we consider the world's largest energy and electricity consumer, China, RE is a big part of their plan to meet INDC targets of peaking carbon emissions by 2030. However, the actual RE targets are modest compared with India on a relative basis. China's National Energy Administration has set a goal for 2020 of 150 GW of solar, but the 2016 target is only for a 15 GW growth of solar capacity and 20 GW of wind capacity. It's worth noting that wind dominates China's RE (excluding hydro), with some 136 GW of wind already installed. In fact, the capacities are already so high that curtailment of RE (which happens when demand and supply don't match, or there is a transmission bottleneck) was reported to be 15 per cent for wind and 10 per cent for solar in the first half of 2015.

Much more importantly, China's installed overall capacity is more than five times higher than India's. Thus, a 150 GW solar target would look like 30 GW solar by 2020 if we consider share of capacity. Even factoring in the fact that wind is going to be much higher than solar, this still means India's 175 GW target is more ambitious in terms of required growth rates and expected share of generation.

While comparing India with the EU, California, or China, we find a dichotomy. Given that India excludes most hydro from RE, the targeted RE share is higher than the EU's or China's but lower than California's (with the caveat that comparisons aren't straightforward). On the other hand, the *growth rates* required for reaching the targets are much higher.

Is "ambitious" vs. "over-ambitious" a problem?

India has historically failed to meet targets in energy growth, though recently it has added more capacity than as per Plans (Five Year Plans). Is the ambitious RE target just a case of an aspirational target, i.e., "Aim for the stars, and you'll at least reach the moon?" If so, there are a few issues with such thinking. This is before we consider the general issue of non-enforcement of targets creating looseness in general enforcement of all norms and rules (a societal challenge of "*chalta hai*").

There are two implications of an aggressive RPO. If one uses the RPO as a base, instead of capacity, then there has to be commensurate growth in RE capacity. Second, assuming that demand doesn't grow proportionally, increases in RE generation come at the expense of other capacity, whereby the share of other generation must fall. Ideally, the PLF of other generation shouldn't fall, and one can simply avoid investments in alternatives (especially the case for a growing economy like India's), but this doesn't always happen. For starters, over 60 GW of coal plants are already under construction, with much more capacity planned (coal plants have a four- to five-year construction schedule, or about an order of magnitude longer than solar plants, and longer timeframes when we consider planning). Second, alternative capacity may still be required to handle the variability and stochasticity of RE. In the short run, given the expected growth of upcoming coal plants, RE growth displaces coal. This is counter to the aim of the amendments to the national tariff policy, which aim to lower the costs of power by utilising existing assets as best as possible.

RE has now become *the* preferred destination for investor capital globally. There is a risk of crowding out investment not just vis-à-vis other supply options but also in efficiency, Smart Grids, and other transformations. In addition, RE doesn't operate in a vacuum. The ecosystem for RE includes transmission investments, balancing requirements, etc. RE also impacts other existing or planned power plants, ostensibly by lowering their PLFs, but also their efficiency. It also impacts the railways (for coal), and even the banking sector, assuming some alternative fuel projects (especially those under construction) are at risk for becoming stressed or even non-performing assets. Admittedly, given typical debt:equity ratios of 70:30, a reduced PLF of a coal plant up to a point is not a challenge for banks, but it certainly hits investor (equity) returns. Ultimately, this raises the broader question of investor appetite for new coal projects.

Investors are increasingly wary of coal, not just because of muted demand, but because the risk of stranded assets will only rise as RE becomes more cost-effective in the coming few years (projections are that storage technologies would become viable in a few years as well, which helps RE manage variability). Investors also worry about carbon, even in the absence of a formal carbon price or market in India. This has been cited as a reason to push high RE, but greenhouse gas reduction can take many forms, including energy efficiency, nuclear or hydro power, as well as industrial improvements to reduce not just carbon dioxide but more potent greenhouse gases. In fact, India has already done well on such counts.

Central and State support for RE, including RPOs: Need consistency and feasible numbers

Many RE supporters have been asking for "meaningful RPOs." The guidelines are certainly a step in this direction (pending, of course SERC directives). However, the devil lies in the details. RE has always been concentrated in a handful of states, those endowed with appropriate natural resources. States used to set RPOs to align with such a reality. Now, if we move to a single and larger *national* RPO, this implies that RE deficient states must fund RE in or purchase RE from in other states, either physically/contractually or through tradeable market mechanisms such as the Renewable Energy Certificates (RECs). RECs have been around, but they haven't been attractive to stakeholders. The low REC prices were a consequence of both modest or low targets, plus non-enforcement of even these targets. It remains to be seen what targets and penalties SERCs would impose on states.

There existed solar and RE targets prior to not just the proposed 2016 updates but even before the 175 GW capacity target. The Jawaharlal Nehru National Solar Mission was one pathway to the prior solar RPO, which had a target of 0.25 per cent solar in 2012-13 poised to grow to 3 per cent by 2021-22. If we examine a compilation by MNRE of state solar RPOs under the older targets, we find even these have been mostly weak, vary enormously across states, and have few states providing visibility of the RPO through 2021-22 (of the ones that do declare it, one doesn't reach the 3 per cent target). Documentation from MNRE also shows that earlier calculations assumed a very high demand for power in 2021-22, of 1,895 BU total demand, which is much higher than even our ambitious baseline in Table 2 . Under such a scenario, the estimated 2021-22 total RPOs would far overshoot the 175 GW capacity. RPOs are one mechanism to entice demand that would, in theory, create a market for greater supply. An alternative mechanism has been compulsory RE on the supply side, such as mandates for coal-producers like NTPC to blend RE (solar) into their sales. This has helped drive supply and helps electricity buyers with liquidity issues, but doesn't address any solvency challenges – the payments by the buyers remain the same. In fact, overhead and risk-reduction via pooling itself has a cost, in return for which we expect lower uncertainty and risk.

A more direct supply-side mandate was attempted by Haryana, which announced on September 3, 2014 that all power consumers above a 500 sq. yards plot size (homes, shops, industry, schools, etc.) would have to have a minimum size of rooftop solar power (3-5 per cent of connected load). This was subsequently "clarified" (some would say watered down) that "mandatory enforcement shall be for the new residential buildings only whereas the installation of the rooftop solar power plants in the existing residential buildings shall be promoted by providing financial incentives. For other sectors even the existing buildings will be covered." Even this isn't being met. Anecdotally, very, very few consumers have thus far set up their rooftop solar PV systems, even almost a year after the original deadline. This highlights the challenges of mandates.

The role of the states cannot be over-emphasised. There is a limit to what the Center can achieve alone. Beyond the statutory role state ERCs have in notifying RPOs for utilities, as well as any penalties, states have to take a call on what makes the most sense for them. One option is for all states to simply mirror the national guidelines, which a few are considering. On the other hand, if any state lowers their targets, this means to reach the national target, someone, somewhere else, has to do more. Past projections aren't a good guide for what to do in the future. For example, solar prices have fallen far faster than predicted. The challenge remains what to mandate, what to encourage, and what to simply enable, leaving the market to come up with the maximum RE feasible.

Perhaps a better system would be to focus on the enabling environment, to make RE more attractive to *all* stakeholders, so there would be bottom-up demand for RE. This doesn't just mean subsidies, as those don't scale, but solutions such as cheaper finance, risk-reduction mechanisms, storage solutions, time of day pricing, complementary peaking and fast-ramping generators, etc. Only then would we find RE truly sustainable. We should certainly have RPOs (ideally with a timeframe longer than three or six years), but we must recognise that these aren't a silver bullet for growing RE in India.

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Author

Rahul Tongia

Dr. Rahul Tongia is a Fellow at Brookings India / the Brookings Institution, and an Adjunct Professor at Carnegie Mellon University, where he was on the faculty for many years with appointments in the Dept. of Engineering & Public Policy and School of Computer Science. His areas of research are broad and interdisciplinary, spanning technology and policy, with domain expertise in energy/power and IT/telecom.

He was previously co-founder and Principal Research Scientist/Program Director at the Center for Study of Science, Technology, and Policy (CSTEP), a Bangalore-based not-for-profit, and instrumental in setting up and was Advisor to the leading bodies for Smart Grids in India, the government's Smart Grid Task Task Force and the India Smart Grid Forum.

His energy work has spanned seminal studies on India's nuclear power programme, importing natural gas, power pricing, and political economy. Current areas of focus include Smart Grids, access to energy, political economy and reforms, and sustainable energy.

Dr. Tongia has a Ph.D. in Engineering and Public Policy from Carnegie Mellon University and a Sc.B. in Electrical Engineering from Brown University.

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No. 6, Second Floor
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