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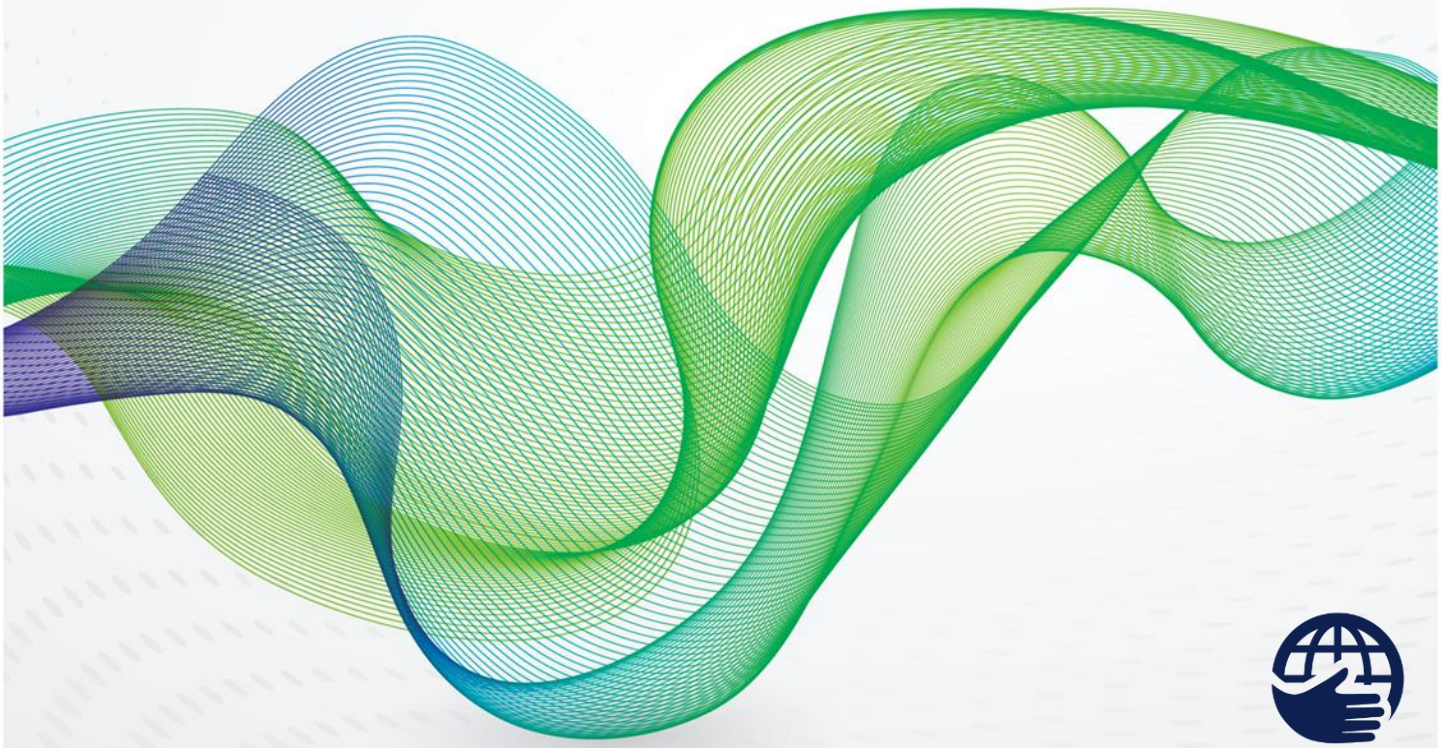
India's Progress on its Climate Action Plan
An Update in Early 2022



Energy Transition

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Executive Summary

India has been implementing climate actions since 2001, when it was one of very few countries to pass an Energy Conservation Act, followed by an industrial emissions trading scheme to force large manufacturing companies to become more energy efficient. A National Action Plan for Climate Change (NAPCC) was passed in 2008, and included relatively modest solar energy targets (20 GW by 2022) along with seven other action areas[1].

Prime Minister Modi, who took office in 2014, brought new momentum to the solar energy sector by raising ambition five-fold[2]. Overnight, the original National Solar Mission target of 20 GW was increased to 100 GW. This ratcheting up of the target was to become the norm. India's growing renewable energy (RE) investment has been underpinned by consistently increasing the level of ambition announced to private investors, domestic and foreign.

Progress on the ground has been remarkable, despite the last two years being disrupted by Covid 19-related restrictions. Installed solar PV capacity since 2014 has grown to 50 GW by February 2022, of which 43 GW are ground mounted and 7 GW are grid-connected rooftop PV. Overall installed renewables (solar, wind and biomass) stand at just over 100 GW. If large hydro is included, the currently installed total capacity rises to 150.9 GW. Around 53 GW of renewable investments are currently at various stages of preparation, contract award or construction. Current milestone targets call for 175 GW of renewables by 2022, and 500 GW by 2030, on the way to net zero in 2070.

Today India has the world's fourth largest installed capacity of renewable energy and the fifth largest installed capacity of solar PV.[3] In 2021, Solar PV accounted for 62% of new capacity addition, which was the largest share of capacity ever in India. Renewables overall accounted for 77% of new capacity addition in 2021. [4] Apart from renewable energy capacity expansion, a number of landmark achievements have also taken place on the energy efficiency front, and these are presented in detail in the paper.

In terms of the big picture, this paper also lays out and examines the conundrum facing India, in terms of the scope of the challenge and the balancing act it is trying to follow between meeting economic development goals and climate goals. Given its stage of development, India still has a huge unfinished economic growth and poverty alleviation agenda as it also simultaneously tackles the climate agenda, using its own budgetary resources.

The Financial Times[5] notes that there is enormous potential for India's development to follow a much cleaner path and quotes the International Energy Agency:

> "More than that of any other major economy, India's energy future depends on buildings and factories yet to be built, and vehicles and appliances yet to be bought . . . This represents a huge opening for policies to steer India on to a more secure and sustainable course."

India should therefore find the path of fewest and smallest trade-offs in terms of its highly ambitious renewable energy goals and its economic growth goals and the right balance to pursue both growth

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[1] See Appendix One for more details on the eight action areas of NAPCC

[2] Kumarankandath, A. "Modi Government sets revised solar target at 100 GW" June 2015 <https://www.downtoearth.org.in/news/energy/modi-government-sets-revised-solar-mission-target-at-100-gw-50236> accessed on March 16th, 2022

[3] National Investment Promotion and Facilitation Agency < https://www.investindia.gov.in/sector/renewable-energy> , accessed on March 21, 2022

[4] Mercom India Research, Q4 2021 and Annual India Solar Market Update https://mercomindia.com/product/q4-2021-india-solar-market-update/ , accessed on March 17, 2022

[5] Mundy, S. "Will India Help or Hinder the Global Climate Fight?" in the Financial Times, March 25, 2022, < https://www.ft.com/content/af8322bb-9a72-49af-8106-0de3ea6daec0> accessed on March 25, 2022

and climate action jointly, without 'consuming' the stock of natural assets (natural capital) that can potentially help it with decarbonization and climate disaster resilience goals. These natural capital assets that are also climate allies, include standing old-growth forests that act as carbon sinks, watersheds and natural wetlands, mangroves that offer coastal protection against hurricanes and flooding, etc, to name a few.

Land availability is a perennial issue in India. Renewable energy investments such as solar parks and wind farms require vast areas of contiguous, non-arable, vacant land for their construction, and subsequent twenty-five-year operation. Vacant land is often in short supply in a country of 1.3 billion people, like India, at least relative to the need.

No international low-cost climate finance resources from so-called "Annex 1 Countries" to the Paris Agreement (this refers to the US$100 billion promised in 2009) are visible on the horizon, and there is no time to wait for them. Thus, India should figure out how to do more with less, within its given budgetary envelope. That is what it has already been doing since 2014.

A Parliamentary Committee has recently noted that the cost of the 36GW of annual renewable energy (RE) capacity required to be installed in India in order to meet its target[6], is $20-$26 billion; yet the available annual RE investment resources at present are around $10 billion. Larger macroeconomic forces and interest policies of central banks in the EU and US will ultimately determine whether India can attract enough domestic and foreign direct investment funds to double its annual rate of renewable energy investment to over $20 billion for each of the next eight years.

India will continue its adoption of good renewable energy policies, a sound private sector investor framework and strict adherence to the rule of law in order to maintain investor confidence and attract external resources to complement and expand existing levels of public and private domestic investment.

If India is able to find a pathway that succeeds in balancing all of the above, and meeting both Sustainable Development Goals and Climate Action Goals, then not only India, but the entire world, will be better off. What happens in India, doesn't stay only in India because India moves the global needle on climate action.

[6] 36GW per year figure taken from: Garg, Vibhuti, IEEFA (Institute for Energy Economics and Financial Analysis), V., IEEFA, June 9, 2020 "Is Renewable Energy Investment on Track?" < https://ieefa.org/ieefa-india-investment-trends-in-renewable-energy-2019-20/ >

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1. Introduction and Objectives

This Paper is written about four months after the COP26 Glasgow meeting of November 2021, where the Indian Prime Minister made some surprise announcements, further ratcheting up the level of India's climate ambition (without any assurance of additional funding).

The objective of this paper is to take stock of the Indian National Action Plan on Climate Change (NAPCC) from its early days in 2008 up to the present, to see how it has evolved in response to national and international events over the past dozen years or so, and to assess the prospects of achieving the updated targets.

The paper also reviews India's progress on developing a home-grown two-pronged "economic development and climate" strategy, for simultaneously pursuing economic growth and poverty alleviation goals (a challenge that is now intensified by the Covid 19 pandemic, relative to pre-2020 performance), jointly with very ambitious climate goals in order to grow the economy in a decarbonized manner. India's approach to this includes a focus on energy efficiency, and also vast addition of renewable energy capacity in order to reduce greenhouse gas (GHG) emissions from its growth activities. After a detailed look at what has happened in the climate journey so far, where we are now, and what the key issues, achievements and challenges are, the paper looks at the conundrum of how to manage a development agenda and a climate agenda simultaneously, without sacrificing one or the other given a limited resource envelope. The paper concludes with a look ahead and identifies reasons for optimism that the climate goals will be achieved, even if they should end up being reached a couple of years late relative to the present deadlines of 2030.

Section 2 traces the series of events that have been taking place from the initial articulation of the NAPCC in 2008, to the present. These are the building blocks and puzzle-pieces for India's eventual "climate and development formula", from which we expect that a first-of-its kind low carbon growth strategy for a country like India will emerge. While the strategy is still evolving, it is important, as an observer of India's climate action progress, to understand the different elements that are either unfolding now, or are being added to the mix at a fast pace. A composite of all these elements will make up the ultimate outcome of how India achieves its targets.

Section 3 focuses on some notable achievements and challenges that have informed the lessons learned so far. It also delves into (mostly in Appendix Two) the detailed mechanics of how low-cost financing/credit directly feeds into determining the renewable energy tariff that will in turn influence affordability of making the change. In other words, the availability of low-cost credit for RE technologies determines how far and how fast such clean energy technologies, particularly solar PV, can be mainstreamed and see widespread and rapid adoption in the marketplace (without which the green energy transition remains incomplete). Too often with renewable energy a mistake is made of thinking that it is all about the supply side. It is *not* a case of "build it and they will come". Rather, it must be built, and it must also be recognized by market participants to be "better" than the fossil fuel alternative that they are using today. Only then will the clean technology be adopted and mainstreamed. But it must be affordable to start with, and this is why lowering the risk perceptions of commercial lenders about RE technologies is crucial. That is one of the major topics of Part Two.

Section 4 addresses the "elephant in the room". It lays out the big picture and the Conundrum. This is formulated in terms of the scope of the dual challenge facing India, and the balancing act needed in terms of its highly ambitious renewable energy goals versus the concurrent need to deliver aspirational economic benefits and good jobs to its people, and at the same time also respect planetary limits and pursue growth and climate action without consuming natural assets that can help with decarbonization goals. The economist Kate Raworth's Doughnut Economics model is very helpful to visualize what India needs to do (even though the Indian government does not explicitly refer to Doughnut terminology at present).

All of this “balancing” of trade-offs by the Government of India is to be achieved within a limited financial resource envelope that is further stretched due to the Covid-19 pandemic. The government is paying to double-vaccinate 1.3 billion people and is also paying rising import bills. Import costs were initially rising for its energy needs as oil and gas costs were already rising in late 2021. Now food import bills are also skyrocketing due to the Ukraine war, which involves two of India’s important trading partners. Meanwhile, no international climate finance resources are visible on the horizon, and there is no time to wait for them.

What will the journey to India’s decarbonization targets look like? There is no formula for this, and it will involve learning by doing at many levels but the building blocks are taking shape at the moment. The last section discusses the likelihood of meeting the ambitious 2030 targets which have been announced, as a milestone on the way to the Net Zero goal of 2070.

2. The Building Blocks—How Did We Get to Where We Are?

Key Takeaways

- **Renwable Energy is well managed in India, and this creates market confidence which in turn attracts investors**. India has been taking climate action since the early 2000s, and its National Solar Mission has been running since 2012; the level of institutional maturity, lessons of experience gained over a decade, and the resultant sophistication regarding renewable energy (RE) price discovery and management of capacity addition through competitive and transparent e-auctions (online) is now relatively high.
- **India has ambitious national targets, and progress in capacity addition to date has been fast**. The country is aiming for 500GW of RE installation by 2030, of which just over 100GW has been achieved by the end of 2021. 50GW of the 100GW cumulative installed RE capacity to date consists of solar PV, of which 43GW is utility scale and 7GW is rooftop/distributed[7]. It is noteworthy that India has installed 50GW of solar PV capacity in around 5-6 years, (whereas by comparison Germany's 59 GW of solar PV[8] in November 2021 was installed over a time span of two decades).
- **Electricity Sector financial difficulties and institutional complexity have not prevented the growth of RE, particularly large-scale RE**. The Renewable Energy (RE) sector is an offshoot of the electricity sector. In India, the electricity distribution sector is fragmented and institutionally complex, with each of the 28 states representing a mini electricity market of its own. All states also retain dotted lines to the federal Ministries of Power and of New and Renewable Energy, from which they receive financial support to implement so-called national Schemes. Most state-owned distribution companies are financially strapped; many consider rooftop solar as a threat to their revenues and imposing integration costs on their last mile networks. Despite this lukewarm attitude of distribution companies, solar PV has been making strides and discoms are "obligated entities" subject to the Renewable Purchase Obligation, which is a regulatory requirement. Discoms must buy RE for around 8% of their total bulk energy purchases.
- **Private solar developers and EPC companies are battle-tested and hardened after building and operating very competitively priced assets in India; they tend to do well if they choose to participate in overseas solar auctions**. Private developers constructing grid-connected RE projects at any given location in a given Indian state, must work through multiple layers of state regulations and decision-making processes, obtaining the necessary approvals and permits, as well as ensuring timely coordination with state and national transmission capacity providers, to ensure reliable access and contractual deliveries to their off-takers/customers. Against this challenging backdrop, the nationwide addition of 10GW of new solar PV capacity installation in 2021 (which was a pandemic year) represents a new annual record solar installation achievement for India.
- **India is now moving to kick-start a large-scale domestic manufacturing industry for all hardware components required for its push to install 500GW of solar PV by 2030**. The first phase of India's revamped National Solar Mission has been primarily based on imported inputs (from China). This approach has successfully built institutional capacity, created market familiarity and investor confidence, allowed commercial lenders to offer competitive financing, and seen consistent oversubscriptions of private sector bids solicited. The first phase,

[7] Mercom India < https://mercomindia.com/product/q4-2021-india-solar-market-update/>
[8] Fraunhofer ISE, Public Net Electricity Generation in Germany in 2021: Renewables Weaker Due to Weather, Jan 17, 2022 < https://www.ise.fraunhofer.de/en/press-media/news/2022/public-net-electricity-in-germany-in-2021-renewables-weaker-due-to-weather.html>

however, is now drawing to a close. In the new phase that is starting in February 2022, India is gearing up for a big push--supported by fiscal incentives--to reduce its reliance on imports and start to manufacture solar modules domestically. In particular. India is seeking to also move upstream in the value chain and is attempting to master the heavily capital-intensive processes of manufacturing polysilicon, wafers, ingots and cells.

- **The climate-oriented domestic manufacturing drive is not limited to solar PV components alone.** It extends to Advanced Chemistry Cell (ACC) energy storage technologies, as well as electric vehicles and semi-conductor chips (there are a total of 13 eligible sectors but these are the main ones related to climate progress). There is also a recently announced National Mission for Green Hydrogen. All of these fiscal incentives are being funded out of the already stretched government budget during a difficult moment when pandemic recovery and Covid-19 vaccination costs are high, and energy and food import bills are rising. It is therefore a testament to the strong climate commitment that the Indian government is showing, in terms of its earnest efforts to meet its internationally announced ambitious climate targets despite these difficulties.

Background 2008-2014

India has had a National Action Plan on Climate Change (NAPCC), since 2008[9]. At the time, it was one of only a handful of countries to have such a document. The initial Action Plan on Climate Change consisted of eight "National Missions"[10]. These encompassed energy generation, energy efficiency, sustainable habitat, water, the Himalayan ecosystem, forest cover, sustainable agriculture and last but not least, "strategic knowledge sharing for climate change". Knowledge sharing and capacity building was important amongst government officials with responsibility for implementing the National Action Plan for a vast and diverse country.

India also passed an Energy Conservation Act in 2001, seven years before its National Action Plan on Climate Change. Further to this Act, the Bureau of Energy Efficiency[11] was created under the Ministry of Power (MoP) in March 2002. The government's early and sustained focus on climate mitigation actions, particularly through the central Ministry of Power and the (separate) central Ministry of New and Renewable Energy (MNRE), has allowed relevant institutions and implementing agencies in the central government to gain considerable experience from "learning by doing" after two decades of operation. Energy efficiency and reduction of energy intensity now rest on a solid institutional framework for delivering on India's recent international commitment at COP26 to, *inter alia*, reduce GHG emissions by 1 billion tons by 2030.

Electricity is a 'concurrent' subject in India, meaning that activities in the electricity sector are implemented jointly by the central government and the respective state governments. Some state governments have less experience or fewer skilled staff. They may require hand-holding, knowledge and implementation support and frequently also financial support from the central ministries in order to deliver on climate actions in their respective states. This adds to complexity, and explains the uneven performance on the ground at different locations throughout the country.

[9] Ministry of Forests, Environment and Climate Change, "National Action Plan on Climate Change" < https://moef.gov.in/en/division/environment-divisions/climate-changecc-2/national-action-plan-on-climate-change/ > accessed on March 18th, 2022

[10] Appendix One contains a brief description of the eight National Missions in the original NAPCC

[11] Bureau of Energy Efficiency, Consumer Outreach: How to Choose the Best Energy Efficient Appliances in India <https://www.beeindia.in/ > accessed on March 16th, 2022

Early Climate Action: National Mission on Energy Efficiency

In the early 2000s, as its main climate action at the time, India was focused on how to implement industrial Energy Efficiency (creation of "nega-watts") in the highest energy-consuming industrial sectors, with the objective of reducing energy intensity of GDP. At the time, solar energy was not yet commercially viable and there was no expectation of, nor visibility to, attaining price competitiveness of solar with the cost of coal-fired power. Therefore, the government's focus was fully on promoting energy efficiency amongst large users.

A sophisticated "Perform-Achieve-Trade" (PAT) industrial energy efficiency Scheme was in development after the announcement of the 2008 Climate Action Plan, and was launched in 2012 by the Bureau of Energy Efficiency with an initial Phase 1 group of 478 industrial units. The innovative design of PAT was based on the EU Emissions Trading System, (EU ETS), and had certainly not been seen in any other developing country till then. Here is a brief description of how it worked, and the heavily energy consuming industries it applied to in India[12]:

> "With the aim to make the industrial sector energy efficient, India's Bureau of Energy Efficiency (BEE) launched its 'Perform, Achieve and Trade' (PAT) scheme... The scheme has set energy efficiency targets for industries. Those that fail to achieve targets will have to pay [a] penalty. PAT has been launched under the National Mission for Enhanced Energy Efficiency, one of the eight missions under the umbrella National Action Plan on Climate Change, launched in June 2008.
>
> In its first cycle of three years, the scheme covers eight energy intensive sectors—thermal power, aluminium, cement, fertilizer, iron and steel, pulp and paper, textiles and chlor-alkali. Together, these sectors account for 40 per cent of India's primary energy consumption. The target is to save 6.68 million tonnes of oil equivalent in these eight sectors by 2015, the first cycle of the scheme. The target for each plant will vary, depending on its size, and will be set by BEE. The nation's thermal power plants are the focus of the PAT scheme as they consume 50 per cent (3.21 million tonnes) of oil equivalent of the total 6.68 million tonnes, which is the targeted saving [by 2015].
>
> …PAT is a market-based mechanism in which sectors are assigned efficiency targets. Industries which over-achieve will get incentives in the form of energy saving certificates. These certificates are tradeable and can be bought by other industries which are unable to achieve their targets. These certificates will be tradeable at two energy exchanges: Indian Energy Exchange and Power Exchange India. The price of these certificates will be determined by the market.
>
> Under the penalty clause, if an industry fails to achieve its target, it will be penalised. The penalty will be calculated on the basis of what remains to be achieved to meet target. This figure is multiplied by the cost of energy today (Rs 10,154 per tonne of oil). The BEE Director further noted: "As each industry will be competing against itself only, it will have its energy consumption in 2010 as its baseline data, to improve upon."

[12] Paliwal, A. "Bureau of Energy Efficiency Launches PAT Scheme for Industries to Save Power", 4th July 2012, https://www.downtoearth.org.in/news/bureau-of-energy-efficiency-launches-pat-scheme-for-industries-to-save-power-38616

National Solar Mission of 2012

At around the same time as the PAT Scheme was rolled out, the National Solar Mission (NSM) was also announced in 2012 in India[13], fully three years before COP21 and the Paris Agreement. NSM had a target of 20 GW of installed ground-mounted grid-connected solar generation capacity, and 2 GW of off-grid capacity, all to be commissioned by 2022. Two of India's western, solar resource-rich states, Gujarat and Rajasthan, started to commission large solar parks in designated desert areas or "wastelands", and thereby kick-started the National Solar Mission through public private partnerships (PPPs)[14].

Where Do We Stand on Solar PV Investment Today?

Today India already has 50 GW of installed solar capacity after only seven years of the solar journey. This is remarkable progress by any measure. Germany for example, has an installed PV capacity today of 59 GW, which was started over two decades ago in 2000, with the passage of its Renewable Energy Act. Goswami (2016) captured the already steady ratcheting-up of India's renewable energy targets in an article titled "*India's renewable energy targets catch the attention of global investors, still need groundwork*"[15]: …

> "After the country's solar power capacity doubled to almost 7 GW in 18 months, some within the government think it is time for an upward revision of the goal of 100 GW by 2022. Such ambition has been central to changing the perception about India's willingness to contribute to the global effort to reduce carbon pollution. In 2014, when Prime Minister Modi announced the 100 GW target, India had 3 GW of solar energy and 33.8 GW of total renewable energy (RE) capacity. The government did not stop there…in January 2015 it upped the 2022 target to 175 GW of RE capacity, including [60 GW of] wind and [15GW of small hydro and] biomass. Can India pull it off? … Unlike before, there is now political support for the RE programme at the highest level—the Prime Minister's office is directly supporting it, [said a senior official]". …Then in October 2015, India pledged that by 2030, non-fossil fuels would account for 40% of the total energy generation capacity".

The shift from more generic National Missions to actual quantitative targets, has helped to attract large investments in renewable energy in India, starting from 2015. The energy think tank IEEFA estimates that $8.4 billion of private RE investment was made in 2019/20[16] alone. So far, in India between 2014-2019, renewable energy programs and projects have attracted a cumulative investment of US$ 64.2 Billion (INR 4.7 lakh crore)[17].The share of renewables is steadily increasing even as the size of total installed generation capacity (which stands at 380 GW today) is also still growing. The renewables percentage is expected to more than double by the end of the decade.

As demonstrated by these investment figures, markets responded quickly to the initial announcement of a 175 GW clean energy target. Of this, 100GW was to be Solar PV (60 GW ground mounted and 40

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[13] Ministry of New and Renewable Energy, December 2012, Jawaharlal Nehru National Solar Mission, Phase II Policy Document < http://indianpowersector.com/wp-content/uploads/2012/12/draft-jnnsmpd-2.pdf> accessed on March 21, 2022

[14] Ministry of New and Renewable Energy, June 2016 edition of Akshay Urja Magazine, page 11-15, <https://mnre.gov.in/img/documents/uploads/6c598b4ebbdb457da74fe61018561f54.pdf> accessed on March 20, 2022

[15] Goswami, U., July 2, 2016, accessed on March 20, 2022 <https://economictimes.indiatimes.com/news/politics-and-nation/indias-renewable-energy-targets-catch-the-attention-of-global-investors-still-need-ground-work/articleshow/53015707.cms>

[16] Garg, V., IEEFA, June 9, 2020 "Is Renewable Energy Investment on Track?" < https://ieefa.org/ieefa-india-investment-trends-in-renewable-energy-2019-20/ >

[17] Verma, K. and Aarushi Agarwal, Strategic Investment Research Unit, Invest India, July 2021, "India's Rising Solar Sector", < https://static.investindia.gov.in/2021-07/Solar%20Report.pdf > accessed on March 14th, 2022

GW rooftop PV). Investment started to flow into all renewable energy generation sources in India, but particularly into solar PV. Goswami (2016)[18] also notes the challenges which include:

> "…accessing affordable finance, the poor financial health of electricity distribution companies and technological challenges—be it grid stability or storage—are at the top of the list…The total investment required to make good on the promise of 100GW solar energy capacity is estimated at [almost US$100 billion]. Financing is available, but the terms are unattractive…adding up to as much as 30% of the cost. The risk of extreme and unexpected currency devaluation needs to be addressed to facilitate foreign investment…The [premier government think tank] Niti Aayog estimates that the cost of upgrading the inter-state and intra-state transmission networks to ease the injection of renewable power into the system is a little more than US$16 billion. Buy-in from the states is crucial"

In order to maintain investor momentum, and the very robust investor response to the initial announcement of the seven-year 175 GW goal in 2015, the Prime Minister continued with the same playbook. In 2019, he introduced a new, increased target of a cumulative 450 GW of RE by 2030, up from 175 GW by 2022. Most recently, the 450 GW RE target has now subsequently been further increased to 500 GW of RE by 2030. This was communicated in another announcement from Prime Minister Modi at COP26 in Glasgow, in early November 2021[19].

Importance of Public-Private Partnerships (PPP) and second generation of Large-Scale Solar Parks

The PPP aspect of the large-scale solar park starting with Rewa[20] (located in the central Indian state of Madhya Pradesh) in 2016, was based on the idea that the respective State government would secure the sites (large areas of contiguous, barren land) and it would then create land parcels for around 250MW per bidder, build access roads, fencing etc, and would invest in order to provide the necessary transmission evacuation infrastructure. This included the intra-park "pooling station" where different private generators would have their delivered energy metered and pooled, before injection to the high voltage transmission line at the switchyard. Previously, large central government companies and experienced parastatals used to handle this type of complex PPP project development. Such responsibility was never taken on by state-level agencies of the kind that were set up for the Rewa Solar Park project, in joint venture with the Solar Energy Corporation of India. This represented an entirely new and untested business model. Meanwhile, as part of their function in the PPP arrangement, private sector companies would compete through a transparent bidding process, to obtain a mandate from the State for placing their solar generation equipment in one or more of the designated land parcels inside the park. Winning bidders earned a 25-year Power Purchase Agreement to sell solar generation to a given off-taker. Winning the bid was only the first step. Private sector companies who offered the most competitive cost per kWh of solar electricity delivered into the grid, would then have to design and construct their plant in their designated site within the solar park, as well as arrange their own source of commercial financing[21] under the Design-Build-Finance-Own-Operate (DBFOO) model that rested on the Power Purchase Agreement (PPA).

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[18] Goswami, ibid

[19] Ministry of External Affairs, 14/12/2021 https://indbiz.gov.in/india-accelerates-towards-mission-500gw-by-2030/ accessed on March 18, 2022

[20] Srivastava, M. "Rewa: A Case Study", May 2017 < http://rumsl.mp.gov.in/wp-content/uploads/rums_media/2020/12/Rewa-a-Case-Study-EN-May-2017.pdf >

[21] Most commercial lenders were demanding a 20-25% equity contribution from the developer, as the upfront or "down payment" on a transaction to ensure that they had sufficient funds at stake to remain financially engaged and solve whatever problems arose, rather than abandoning the project and thereby jeopardizing recovery of the loan contribution.

Srivastava (2017)[22] makes a number of interesting points in his case study on the Rewa Solar Park in the State of Madhya Pradesh, including the important point that *this was the landmark large scale solar project in which solar achieved grid parity in India without any subsidies* (or so-called Viability Gap Funding, VGF). He notes that bids were received for 7,500 MW, exactly ten times the amount of the 750 MW capacity of the park, i.e a ten-fold oversubscription. Also, Rewa Solar Park sells around 24% of its solar generation across state lines to the Delhi Metro Rail Corporation, (DMRC), another first of its kind transaction. This feature of the landmark Rewa project gave confidence to other potential investors that a truly nationwide market of solar off-takers existed, including commercial buyers like DMRC. In other words, the universe of solar buyers (PPA signatories) was not limited to just the financially struggling state electricity distribution company (discom) of the same state where their generation investment was located.

India's very first two large scale solar parks (Charanka in Gujarat, at just under 800 MW for which Phase 1 construction began in 2010 and commissioning date was 2012) and Bhadla in Rajasthan[23] (2.25 GW, of which construction started in July 2015 and the first phase was commissioned in October 2018)) are still going strong. The construction and commissioning experience that was gained around a decade ago, as well as the auction design conducted by the government, offered a valuable and steep learning curve to a wide range of stakeholders and certainly helped to underpin the success of second-generation solar parks like Rewa. The groups benefiting from the learning included the private sector solar generation investors, their commercial lenders, the State governments, intra-state transmission utilities, and above all the State-owned electricity distribution utilities. The latter were required to off-take the (still very expensive in 2012) solar power, integrate it to their grids, and distribute it to end users at a blended tariff (i.e blended with thermal power cost).

Government Support

As mentioned earlier, India has been steadily increasing its stated level of ambition as far as clean energy investments are concerned. Markets have responded positively, because the ambitious announcements have always been supported by conducive government policies favouring renewable energy investors. Policies have included the imposition of Renewable Purchase Obligations on energy buyers (RPOs, or mandatory purchase of renewable energy generation, mainly by electricity distributors, up to a percentage of their overall bulk energy purchases). Other policies appreciated by RE investors have included waivers of inter-state transmission fees in order to enlarge their market of off-takers; and conferring "must-run" status for renewable generation plants, which puts them at the front of the queue to use the (sometimes capacity-constrained) transmission facilities.

Another accommodation which was made for RE investors, was to allow them to sign Power Purchase Agreements (PPAs) with creditworthy central government entities, such as Solar Energy Corporation of India (SECI) or NTPC. These central government entities actually had no plans to use the RE they were buying from diverse private solar generation investors. The state-owned distribution companies (discoms), who were the actual distributors of the solar electricity to end-users, were in weak financial shape. Private sector RE investors (and their bankers) were often not satisfied to engage contractually with such discoms, as they were un-creditworthy counterparties or off-takers and their promises to pay were seen as risky. Therefore, in order to overcome investor hesitancy, a central government entity stepped forward and signed a Power Purchase Agreement (PPA) with a renewable investor. The central government entity then off-loaded the solar energy to an end-user such as a state discom, through a back-to-back Power Sales Agreement (PSA) between e.g SECI and a discom. This is still very much the case today.

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[22] Srivastava, M. ibid < http://rumsl.mp.gov.in/wp-content/uploads/rums_media/2020/12/Rewa-a-Case-Study-EN-May-2017.pdf > accessed March 19, 2022

[23] Climate Investment Funds. "Bhadla: Solar Parks Transform India's Energy Landscape" < https://www.climateinvestmentfunds.org/CIF10/india/bhadla>

Steep Learning Curve, Tumbling Prices of Solar Electricity and early PPAs

Just as a point of reference, price discovery from the earliest solar auctions yielded per kWh costs of around Rs 17/kWh ($0.38/kWh), then falling to Rs 15/kWh and subsequently Rs10-12/kWh ($0.22-$0.27/kWh) by 2016/17. The dramatic cost declines in solar panel prices imported from China came from 2016 onwards, and since 2018/19, fiercely competitive solar auctions have resulted in bids of below Rs 3/kWh (below $0.04/kWh[24]). For comparison, when the early solar auctions were conducted, thermal electricity produced by burning coal was priced between Rs 3-4/kWh ($0.06-.09/kWh at then prevailing exchange rates), so the *unit cost of solar PV was fully three to four times as high as coal in 2012-15*. It seems remarkable in hindsight that the construction of the earliest solar parks nevertheless went ahead, despite such a large price differential in the cost of solar versus thermal energy.

Other than the 2008 National Action Plan for Climate Change (NAPCC), it is difficult to follow the justification on which the two State governments (Gujarat and Rajasthan) could have actually signed 10-and 15-year Power Purchase Agreements (PPAs) for those astronomical prices, in order to proceed with the first-generation solar parks of Charanka and Bhadla. They were literally committing their respective State electric utilities to pay between three and four times higher than the available prices in the thermal power market at that time, for the next 15 years. It reflected the government's commitment to making an investment in learning and acquiring the necessary institutional experience for creation of the eco-system for a green energy transition, based on a conviction that renewable energy was here to stay. This recognition was gained and acted upon at least three years before the Paris Agreement which is also remarkable and indicates the home-grown nature of India's climate actions.

As solar PV prices tumbled in the succeeding years, the original high-cost PPAs were unsuccessfully challenged in court by the State of Gujarat. Subsequently, some of the earlier high-priced PPAs were also challenged in the States of Andhra Pradesh and Punjab.

A July 2019 research note[25] from JMK Analytics points out where the controversy lies:

> the new Chief Minister [of Andhra Pradesh] believed the agreements he inherited from the outgoing administration were signed at higher rates than in other states, and "in his view, the higher rates could be attributed to corruption". To the dismay of many state officials[26] who had approved the original PPAs, newly discovered solar auction prices, (which were often bid by the same developers), continued to fall sharply (e.g in 2017 they fell to about Rs 3-5/kWh compared to the Rs 11-17/kWh on the legacy 15-year contracts).

Unfortunately, as the legacy contracts were still early in their 15-year validity period, it meant that the successful, first-mover developers were going to continue to enjoy receiving Rs 11-17/kWh on the old contracts for at least another decade. This was very uncomfortable for state authorities to defend, i.e explaining to the public why State utilities were paying Rs 11 and more per unit on some earlier contracts, when the same developer agreed to accept Rs 5 per unit for the same "service" of delivering solar energy generation, on a later contract with another counterparty. However, the court upheld the sanctity of the legacy contracts as signed. It ruled that subsequent price declines of solar equipment could not affect the terms of what had been agreed in the original, earlier contracts. This also provided relief to the commercial lenders, who had calculated the stream of debt service payments and loan terms according to the original, higher project costs. The solar bulk tariff paid by distribution utilities (and eventually passed on to customers through the regulatory formula) essentially reflected these debt

[24] Estimated rupee to USD exchange rate of Rs 75:1

[25] July 15, 2019 JMK Research Note: "Andhra Pradesh PPA cancellation/ renegotiation controversy: Acme, Tata, Vector Green and Greenko assets at maximum risk" < https://jmkresearch.com/andhra-pradesh-ppa-cancellation-renegotiation-controversy-acme-tata-vector-green-and-greenko-assets-at-maximum-risk/ >

[26] In turbulent local Indian state-level politics, this situation is likely to invite accusations of collusion and corruption from political opponents

service terms. They were higher because they were applicable to a higher underlying project cost and hence a larger loan that the early contracts had been associated with.

From Large Import Demand to domestic manufacturing

On a related note, the widely-accepted explanation for the sharp decline of solar panel prices starting around 2016, lies in the manufacturing boom in China. Solar manufacturing capacity in that country was vastly expanded to meet demand from the global market, as well as to cater to China's own very large domestic solar PV investments. Chinese economies of scale and overproduction to some extent, are what made the global cost of *solar PV competitive with thermal power about a decade earlier than forecast*. Yet it is rarely mentioned that the very large order volumes from the Indian solar market in particular, substantially helped to accelerate and make possible those massive Chinese economies of scale. That in turn brought down costs for everyone else, and hastened the global competitiveness of solar PV to grid-parity with thermal power.

India's ground-mounted solar program started a decade ago with imports of thin-film CIGS modules from the United States, under a program supported by US EXIM financing (because absolutely no Indian commercial lenders were offering financing for solar technology in 2012, due to unfamiliarity and a very high perception of risk). Imports from the US were supplemented by a nascent domestic solar module manufacturing capacity. Thereafter, the Indian solar program became mainly reliant on imported Chinese solar modules (and inverters and other power electronics) for its entire rapidly growing domestic solar installations from 2015-2020.

Following a 2020 border clash with China, there is now a revised import policy in India. Basic customs duties are being imposed for solar module imports (along with a range of other imported products) from China. India has been moving fast since 2021, and offering generous fiscal incentives, to expand and ramp up its domestic production capacity related to the green energy transition.

Some market watchers are apprehensive that the shift to domestic manufacturing may take a few years for setting up the required giga-factories. This could interrupt the rapid pace of solar capacity addition that occurred in the first phase, which was achieved using imported Chinese solar modules. Regardless, the Indian government feels that in order to secure its supply chain, the "gear-shift" to domestic high-efficiency module manufacturing is unavoidable.

India is launching a climate-oriented domestic manufacturing program in 2022, supported by central government budgetary contributions (Production Linked Incentives, or PLI) to reach its climate targets. The government's PLI Scheme for climate action comes in separate sub-components and covers the domestic manufacture of high-efficiency solar modules, as well as polysilicon, wafers, cells. It also includes research and development in Advanced Chemistry Cell (ACC) battery energy storage, and separately, the domestic manufacture of electric vehicles suited for India's difficult road and high ambient-temperature conditions.

Financially strapped electricity distribution utilities owned by the respective States in India, were never excited about their Renewable Purchase Obligations (RPOs). They were even more disenchanted at having to pay over twice as much as the going thermal power rate, for purchases from new solar investments. The RPO was a key demand-side policy instrument with which solar energy was made bankable in order to unlock domestic commercial funding.

The central government essentially "forced" so-called "obligated entities" in the States, to purchase the (initially expensive) solar energy which was being generated in the growing utility-scale projects that were coming up under the National Solar Mission of the NAPCC. Most of the obligated entities were electricity distribution companies (known as discoms in India), and the rest were large industrial energy consumers. The RPO policy was implemented through the State Electricity Regulatory Commissions (SERCs). It was initially set at 2%, then rising on a glide-path to around 10-13% over time. The RPO (which varied by State) indicated the percentage of a discom's energy purchases which had to be

renewable. When these obligatory purchases were observed to be gravitating mostly towards purchases of wind energy (which had a slightly longer history and was more competitive at the time), some States even saw the introduction by their Regulators, of a "Solar Purchase Obligation" to ensure a ready market in order to encourage solar investment.

Commercial Banks and Private Investors were Drawn in to Financing Solar based on the PPAs

These initial "solar obligations" on discoms were the only way to create market demand for high-cost solar energy at the time. This "reliable demand" in turn resulted in signed Power Purchase Agreements (PPAs) between the private solar generation companies, and the State-owned discoms. The PPA was the entry point to obtaining commercial Non-Recourse Project Finance for the projects. The loans were to be repaid only from the cash flows of the project, and were not collateralized by the sponsors' other assets. This was the most expedient way forward in a situation where very few of the bidders had adequate track records in building and operating large ground-mounted solar plants. The bidders were also unfamiliar with the project risks and were not willing to pledge all their existing assets on this unknown, new business line. This hesitancy by investors was understandable, since large ground-mounted solar plants had not previously existed in India. Hence non-recourse financing was one of the key success ingredients for the rapid development of large-scale solar PV investment in India. The key message is that in the absence of any international, Paris Agreement-supported climate finance resources for the large-scale solar sector, everything centered on the Power Purchase Agreement contract between the solar developer and an off-taker. The PPA was the document which made financing possible, and the RPO was the policy that led to the PPA. This is a clear example of improvisation in the Indian market, instead of waiting for a part of the $100 billion international resources to materialize.

Private investors had to arrange their own commercial debt financing for the solar PV investments, and in some cases, they also had to identify and buy the land for their solar generation site, and even take a loan to build the transmission inter-connector to the nearest grid substation, in order to evacuate the power from their own, isolated generation site. Unlike in many other countries, there was no financial "coddling" of solar investors from the Indian government. On the contrary, the government placed the Renewable Purchase Obligation onto the pool of energy-buying customers, to ensure that developers were helped by having a ready off-take market at the outset. All investment was to be private and commercially financed. There were no sovereign guarantees to lower borrowing rates in the first round of projects. This is another explanation for why the early, expensive PPAs reflected very high debt service costs.

After the initial round of only private investors as first movers, others started to join the solar investment opportunity. In particular, in 2015 when the solar targets were increased five-fold overnight from the initial 20GW, many large parastatal companies mostly owned by the central government, were also encouraged or nudged to invest their surpluses into solar energy. Instead of depositing their financial surpluses as dividends to the Ministry of Finance, they now used them to commission EPC (engineering, procurement and construction) companies to submit bids to build solar generation projects for them. The parastatals, as owners, would then either sign PPAs to supply their solar generation to other off-takers, or alternatively, they could self-consume the output in order to "green" their own operations.

Parastatals played a unique role as first movers in taking on risky solar projects with still "unproven" technologies. The public sector companies (meaning ones that were owned by the central or State governments) could do this because they were self-financed and were not looking for loans; their projects were often all equity-financed. This meant that they did not have to wait for a risk-averse commercial bank's Credit Committee approval. Some of the first floating solar projects in India were commissioned in this way, by public sector companies who could afford to take greater risks with unproven technologies. The most interesting aspect of parastatal companies building solar projects

using experienced, private companies as their EPC contractors, was that *a number of parastatal coal-mining companies and coal-fired thermal power generation companies also suddenly became the owners of large solar projects through this route*. Yet another benefit of the parastatal companies' engagement with solar was that Indian EPC companies who carried out design, construction and commissioning for the parastatals, gained considerable market experience in frontier technologies that they would otherwise have been unable to obtain. This learning curve ranged from costing and bid submission all the way to successfully commissioning the plant and operating it. The robust climate investment eco-system that exists today and will take India ahead to meet its climate goals, has been built over the last decade through the contributions of this diverse set of actors.

In the early days of ground-mounted solar auctions (2014-2018), the continuously declining cost of (imported) hardware for solar projects was paradoxically a great source of heartburn for the off-takers, who were mainly discoms. Every year, price discovery through auctions was revealing lower prices and creating heavy discom regret at having recently signed a higher priced multi-year contract. In fact, adopting a 'wait and see' posture would have become the preferred discom behavior, were it not for the Renewable Purchase Obligation policy[27].

Fierce competition to win contract awards among private solar generation investors also led to what some called "a race to extinction", or "unviable", or "overly aggressive and suppressing domestic industry"[28]—all this was said about record low bids that were hard to explain, given the cost information known to everyone. Such inexplicably and excessively low bids were therefore considered aggressive/predatory. A Guardian article of May 2017[29] picked up the story and noted that analysts called the 40% price drop (from the recent, previous auction) "world historic". The Indian government officials and bureaucrats who were conducting the price discovery auctions, were of course self-congratulatory at such a "world historic" success of their program, represented by the unanticipated, steep decline in quoted tariffs; the officials were not worried about "extinction" of key private sector players. They simply said that there were multiple players coming forward to bid, and that the "bidders had obviously done their arithmetic", as the article notes. Developers privately revealed in market soundings, that they had figured out that their hardware and materials would be procured only around six months after contract award and signing, so they were counting on further price declines in China. They fully anticipated price declines and built these into their bids (hence the seemingly "irrational" appearance of the winning bids that were impossibly low based on current costs, but were actually based on assumptions of continuous future cost declines). This is explicitly referred to in the same article by D'Monte[30]:

> Asked how SBG Cleantech was able to make such aggressive bids, beating its own Rs 4.34/kWh, set 18 months ago, executive chairman Manoj Kohli said the most important change in the global solar sector was that the price of solar modules – which are largely manufactured in China – had come down by 35% in 18 months.

[27] The RPO also came with a companion policy of Renewable Energy Certificates (RECs), whose price was to be determined through market transactions. For discoms unable to fulfil their RPO, there was the alternative of buying RECs in the secondary market, from discoms that had more than fulfilled their RPO and were in a position to sell their surplus renewable energy purchases. However, the REC market quietly withered away because so many discoms were financially strapped and unable to purchase RECs, that the anticipated secondary market never took off. The State Energy Regulatory Commissions who were supposed to enforce the REC market, quietly let it go dormant for some time, due to the liquidity crunch faced by most state discoms.

[28] D'Monte, D. "India's Tumbling Solar Prices A Race to Extinction", June 8, 2017 < https://www.climatechangenews.com/2017/06/08/indias-tumbling-solar-prices-race-extinction/> accessed on March 20, 2022

[29] Safi, M., The Guardian, "Indian solar power prices hit record low, undercutting fossil fuels", 10th May, 2017 < https://www.theguardian.com/environment/2017/may/10/indian-solar-power-prices-hit-record-low-undercutting-fossil-fuels> accessed on March 21, 2022

[30] D'Monte, D, Ibid

> "This is a global phenomenon led by China, and has nothing to do with the Indian market specifically. Everyone who is buying from China has benefited," he said.

By 2017, the nominal price of a kWh of solar electricity had fallen below that of coal. In addition to record low prices of hardware imported from China at the time, Solar PV also benefited from two Indian policies which included a "must-run" status, and a waiver of transmission charges, and of course large numbers of bidders, intense competition, and frequent oversubscription where bids were received for many multiples of the capacity that was actually available to be awarded. All these factors spurred on the growth of India's solar PV sector before the pandemic.

State-level Electricity Distribution and Transmission Companies

One major shortcoming in the national solar program was a communication failure on the part of any central Ministry entity, to educate the market, and this created unnecessary distraction and noise. There was no outreach, nor attempt to invest effort in raising market awareness and creating a broad-based understanding about declining costs. Most people are used to costs going up over time, not down. Fingers of suspicion were therefore pointed at the holders of early and more expensive solar PPAs, and there were unfortunate allegations of possible collusion amongst stakeholders[31]. Distribution companies that felt arm-twisted into meeting their Renewable Purchase Obligations through signing on to the high-priced early contracts, were actually unhappy to see solar costs coming down fast for others behind them in the queue, as it shone an un-favourable spotlight on them, raising questions on why they were apparently "overpaying" for their kilowatt-hours of solar. Some of this friction could easily have been avoided if central agencies had stepped in with some public announcements indicating that the declining cost phenomenon of solar PV was a global one, and was related to economies of scale that were helping India to reach its climate goals faster—something of that sort would have been helpful, in hindsight.

Newcomers in government circles instead went head-to-head with solar developers, and demanded that the latter immediately lower their prices on older and more expensive PPAs, to match the new, record-low tariffs that were resulting from competitive auctions. Very few of the new administrators (who were in disbelief at the glaring price disparities for the same product, i.e. solar electricity), were quick to see that the pricing decisions were actually coming out of China. Indian bidders were not at all at liberty to slash their prices on a whim. They had paid the earlier, higher prices, and were now locked into a debt service stream to repay their larger, older loans. The only way they could repay on time was by collecting higher tariffs/revenues from their early customers. These revenues were used to pay their debt service. If they slashed their tariffs as demanded of them, they would default on their loans. This is something that the Ministry of New and Renewable Energy could have and should have, taken upon itself to let all market actors understand very well, early on, as noted above.

Many indicated that irate state-level decisionmakers failed to heed and appreciate explanations that the original private investors had faced much higher equipment prices several years ago, as "first movers", and were therefore committed to paying higher debt service costs that were then reflected in higher tariffs for distribution companies. They would have liked to pause their solar investments and adopt a wait and see attitude for prices to fall further, but they were subject to the Renewable Purchase Obligations, which did not allow them to slow down their solar PV purchases. Meanwhile supporters of coal fired power plants were throwing shade on solar and complaining in a low voice about the "unfair" favourable treatment it was receiving. They could not point to direct subsidies, as there were none, but they referred instead to waivers of transmission charges and must-run status, and of course RPOs.

[31] Singh, S. C. "Can't Renegotiate PPAs, Clear RE Dues in 6 Weeks: AP HC on Reneging Matter, March 15, 2022 https://economictimes.indiatimes.com/industry/energy/power/cant-renegotiate-ppas-clear-re-dues-in-6-weeks-ap-hc-on-ppa-reneging-matter/articleshow/90231424.cms accessed March 16, 2022

State transmission companies for their part, were less worried about levels of solar tariffs, but more worried about having to invest in additional transmission and weather forecasting equipment and automation software for successful grid integration. All this was needed to manage the intermittency of increasing shares of wind and solar energy on their networks. State grid operators already saw intermittent renewables as problematic on grid stability grounds, and in terms of disturbing the quality of power supply.

Political Support

The above comments on distribution and transmission companies are meant to confirm that there were a non-negligible number of negative and skeptical voices on the topic of renewables, and specifically the desirability of grid integration of solar, around five years ago, in 2016-2018. Long-time India renewable market watchers will readily recall that at almost all conferences during that time, there were routinely questions raised about why the country was sabotaging and neglecting its "trusty and trouble-free" coal plants that were now lamentably operating at below 50% of capacity (plant load factors sometimes fell to the 40% range, due to must-run policies for solar). Die-hard supporters of coal-fired plants demanded to know what was the need for pivoting to new and troublesome or even "experimental" technologies like solar PV. Without a very strong push from the top, it is highly unlikely that solar energy would have taken hold in the way it did, in a decentralized India where every State has the power to determine how its electricity sector operates.

The Chief Minister of the State of Gujarat during that State's very early (first in the country, as Charanka solar park started construction in 2010) embrace of solar parks, was Mr. Narendra Modi, who later became the Prime Minister of India. Mr. Modi was a strong supporter of solar energy and took an interest in the overall electricity sector. As Chief Minister he had overseen the so-called rural feeder separation (Jyotigram[32]) scheme in rural Gujarat which strengthened the finances of his State's distribution companies and made them the best performing public-sector owned electricity network in India. Several scholars of the Indian energy sector, including Shidore and Busby (2020)[33] have attributed India's "top-down embrace of solar energy" to the personal engagement and personal initiative of Prime Minister Modi in this area.

One of the so-called "five elixirs" offered by the Prime Minister at COP26 in Glasgow was a commitment to reduce 1 billion tons of GHG emissions by 2030, just a short eight years from now. This is nearly as dramatic as the overnight five-fold increase in the solar target announced at the beginning of the Modi administration. The question is whether enough investment, technology and know-how will once again be available domestically, or could flow in from outside investors, to allow the hefty emission reduction target to be realized.

India has immense geographical, cultural and political diversity. There is also the Constitutionally-granted "concurrent" power of States to exclusively decide what happens with all electricity matters inside their individual territory. The central Ministries can only issue "guidelines" on what should take place, but adoption and implementation of the policy happens based on what the State chooses to do. State level policy makers and politicians have the power to decide what they will do in the case of "concurrent" subjects like electricity. They must formulate state-level policies and conduct the implementation. When the central government offers a 'carrot' such as financial incentives and grants and concessional loans for those who join its "Schemes", the State has the choice to opt-in or opt-out. The central government can only watch from Delhi. Therefore, it is no exaggeration to say that the start of the Modi administration offered the briefest window of opportunity for solar energy to capture the

[32] Sakaria, S., Suresh Vaghasiya "Innovation in Power Distribution—A Case Study of Jyotigram Yojana in Gujarat" https://www.researchgate.net/publication/323357791_Innovation_in_Power_Distribution_-_A_Case_Study_of_Jyotigram_Yojana_in_Gujarat

[33] Shidore, S. and Busby, J. "What Explains India's Embrace of Solar? State-Led Energy Transition in a Developmental Polity" LBJ School of Public Affairs, University of Texas-Austin, 2020

national imagination, and it was successfully seized. The years of 2014-15 were truly a rare time for India when most of the country was ready to fall in line with the new clean energy vision offered by a newly elected Prime Minister who had assumed office with a resounding political majority.

States were for once eager to collaborate en masse with the new administration at the central government, having read the signals from their electorates. They moved quickly to identify large areas of contiguous land for solar parks in order to meet the incredible-sounding, newly announced 100 GW national solar target[34]. They also directed their state renewable energy agencies to quickly formulate policies for rooftop PV and net metering guidelines. Training programs for rooftop PV installers were rapidly set up. An upfront capital subsidy program was introduced for residential rooftop PV investment using domestically manufactured solar panels.

States are also aware of their own climate vulnerabilities to violent weather events like hurricanes, floods, droughts, heatwaves and wildfires. Each state needs to look into its own adaptation investment requirements and seek funding support to manage those investments in a timely manner. Fortunately, a few of the states with weaker capacity are receiving technical assistance and knowledge support from some of India's bilateral assistance partners in terms of updating and revising their State Action Plans on Climate Change in the light of new data and information that has been collected since the plans were first drawn up in 2008-2010.

Going even further, in addition to the domestic manufacturing production linked incentive (PLI) program, there is also an ambitious, centrally funded Scheme underway since 2019 to extend the use of solar power for water pumping, to farmers (known as PM-KUSUM[35]). The intention of this Scheme is to wean farmers off the use of fossil-fuel powered irrigation pumps and/or the cost-free coal-fired electricity that farmers currently receive in most states to operate their electric pumps. PM-KUSUM will help farmers to acquire and use solar-powered irrigation pumps instead (helped in most cases by a 90% upfront capital subsidy from the government). The incentive to the farmer is not only an end to diesel purchases (or in some cases unreliable coal-fired electricity supplies) but also the possibility to sell surplus solar power back to the local electricity distribution company and thereby financially benefit from "two harvests" per unit of land, i.e one for the crop and one of solar energy.

Energy security has been a major preoccupation of every Indian administration. In the current fiscal year India is again set to spend over US$100 billion on crude oil imports, as international oil prices trade at seven- year highs[36]. The country is the world's third largest crude oil importer, and in February 2021 it was importing just under 4 million barrels per day, mostly from the Middle East (Iraq) and the US, to meet about 84% of its crude oil requirements. Nigeria was the third largest oil supplier[37]. India has always been a price-taker for oil, subject to the volatility of international energy market price movements. A large and rising share of foreign exchange reserves is spent on fossil fuel imports. (The imported crude oil is turned into petrol and diesel at Indian oil refineries, and is sold to automobiles and other uses).

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[34] In fact, 60GW of the 100GW were to be ground-mounted, utility scale solar installations, and the remaining 40GW were to be solar rooftop installations. The ground mounted targets are progressing well, whereas the rooftop target is still lagging far behind schedule. The pandemic is part of the reason for the slow progress with rooftops, apart from additional complicating factors of cash-strapped distribution utilities that are reluctant to approve what they see as a loss of electricity sales revenues, and of course the additional stresses on the distribution grid which require investments and upgrades to manage intermittent renewable energy injections.

[35] See the KUSUM website https://www.india.gov.in/spotlight/pm-kusum-pradhan-mantri-kisan-urja-suraksha-evam-utthaan-mahabhiyan-scheme accessed on March 21, 2022

[36] Published on Feb 27, 2022 <https://www.orissapost.com/indias-oil-import-bill-nearly-doubles-to-top-100-billion-in-current-fiscal/> accessed on March 19, 2022

[37] Published on April 12, 2021 < https://www.livemint.com/news/india/why-is-india-set-to-review-its-oil-import-contracts-11618157270795.html> accessed on March 20, 2022

Breaking the Indian energy sector's dependence on imports and seizing an opportunity to gain increased energy autonomy, is the national watchword of the Modi administration, offered as a key underlying rationale for the sharp shift towards an updated energy mix. This has been used to rally disparate national interest groups around propelling climate action and generating support for a switch to increased investment in renewables. REN 21, the global renewable energy multi-stakeholder network, had listed India as far back as 2016 [in its 2016 Global Status Report[38]] as being among the top five countries for renewable energy investment. Today India has the world's fourth largest installed capacity of renewable energy and the fifth largest installed capacity of solar PV.[39]

The International Solar Alliance (ISA)

The national embrace of renewable energy was subsequently turned into a substantive Nationally Determined Contribution (NDC) at the Paris COP 21 meeting early in the new Modi administration. India's climate commitment went further, and resulted in the creation of the International Solar Alliance (ISA) as a joint Indo-French initiative announced by Prime Minister Modi and then French President Francois Hollande at COP21 in Paris. ISA was to be headquartered in India and serve as an advocacy organization initially for 122 developing and least-developed countries located between the Tropic of Cancer and the Tropic of Capricorn. Eligible ISA members had abundant sunshine and solar resources, but no access to technology to turn the sunshine into affordable clean electricity. They were deficient in access to energy required for their development and were reliant on fossil fuels because these were the only accessible resources. Most countries were very small and represented unattractive and risky markets for private investors. When and if they conducted solar tenders, they were either obtaining no responses from the market, or very few high-priced bids.

One of the objectives of ISA was to use India's hefty market size and bulk procurement power through demand aggregation to place large orders from other (smaller) countries for solar panels and other generation-related hardware. It was believed that being part of very large orders would attract the attention of vendors and suppliers in a way that small countries were not able to do on their own. (This demand aggregation idea was built on India's energy efficiency experience with the LED bulbs that were bulk procured by EESL, described in detail in another section of this paper). Under India's leadership, ISA member countries could receive help, benefit from India's market size, and participate in aggregated purchasing support to trigger increased competition among vendors and suppliers, with the expectation of leading to more favourable pricing than they could achieve on their own. This in turn would help to alleviate their energy shortages predominantly through solar energy solutions instead of fossil fuels. This is one of the original objectives of ISA, which was also formulated by the Prime Minister for about a year before its announcement at COP21 in Paris.

[38] "Renewables 21", accessed on March 20, 2022 < https://www.ren21.net/gsr-2016/> (GSR 2016 full report is downloadable from this link)
[39] Ibid < https://www.investindia.gov.in/sector/renewable-energy> , accessed on March 21, 2022

3. Achievements and Challenges

Key Takeaways

- The premier Indian government think tank Niti Aayog estimates that the Indian renewable energy market investment opportunity stands at US$20 billion per year, which is an optimistic estimate of the cost of required capacity addition of around 36 GW per year in order to attain the 500GW target by 2030. (Others have estimated the investment requirement for 36GW of RE, at US$26 billion a year). In practice, however, the available funds that have been mobilized so far from domestic and international private and public sources, amount to about $10 billion per year. Of this US$10 billion figure, US$8.4 billion were from private sources in 2019/20. International climate finance, if it were available, would accelerate progress. However, in its likely absence, India is still making large strides, having surpassed the milestone of 100GW of installed RE capacity already.
- The Indian solar sector had a record performance in CY2021. Solar installations of over 10GW in CY2021 were the highest ever recorded in India. Cumulative solar installed capacity in India was approximately 49GW at the end of Q4 2021, and 50GW by February 2022. Renewable energy sources accounted for 77% of total new power capacity added in 2021, a clear indication that the shift to clean energy has commenced in India.
- A solid institutional framework for Rooftop Solar exists in most Indian states.
- Government companies (public enterprises) are being "nudged" to do their part in meeting the national RE targets, and wind or solar plants were commissioned all over the country, by various public sector entities. These government-owned companies have been investing a part of their surplus earnings into RE capacity addition (instead of returning these funds as dividends to the Ministry of Finance). They are often at the forefront of commissioning the most innovative and hence risky tenders. This is because they do not need to resort to commercial borrowing and attempt to convince banks to accept risks. Their projects are fully equity funded and hence they are providing demonstration projects that can later be replicated by the private sector with commercial borrowing.
- India has been very successful in pursuing energy efficiency and has demonstrated global leadership in lowering the cost of LED bulbs to reduce the energy consumption and cost of household lighting, with no subsidy and only through demand aggregation. Widespread use of LEDs also helps in cutting GHG emissions from decreased energy use and flattens evening peak demand, which in turn saves on the need for additional generation investment. India has also implemented the world's largest municipal street-lighting program by replacing incandescent bulbs with LEDs and saving money for municipalities on their electricity bills.
- By early 2022, the number of LED bulbs distributed under UJALA has reached 368 million, and the cost has come down by 85%. The UJALA program in seven years has saved an estimated 47,778 million units of electricity per annum.
- India's Climate Action Plan is unprecedented in terms of its scale and ambition, primarily because the country is trying to implement an energy transition while also growing the energy sector and per capita energy consumption, and trying to meet all of the 17 Sustainable Development Goals for at least 50% of the population (650 million people).
- A successful clean energy transition rests on technologies which help to decouple economic growth from increased emissions. India is investing in R&D in order to avoid confronting a situation of having to pay intellectual property rights (IPR) premiums to access clean technology.
- India is Self-Funding its Energy Transition so far. To date, nearly all climate mitigation investment efforts have been undertaken with domestic public and private investor resources, sovereign-guaranteed borrowing or external private commercial investment (foreign direct investment, FDI) and commercial loans or green bonds. The estimated requirements are US$26 billion but the available funds are US$10 billion.

Achievements

The energy transition in India is happening in four forms:

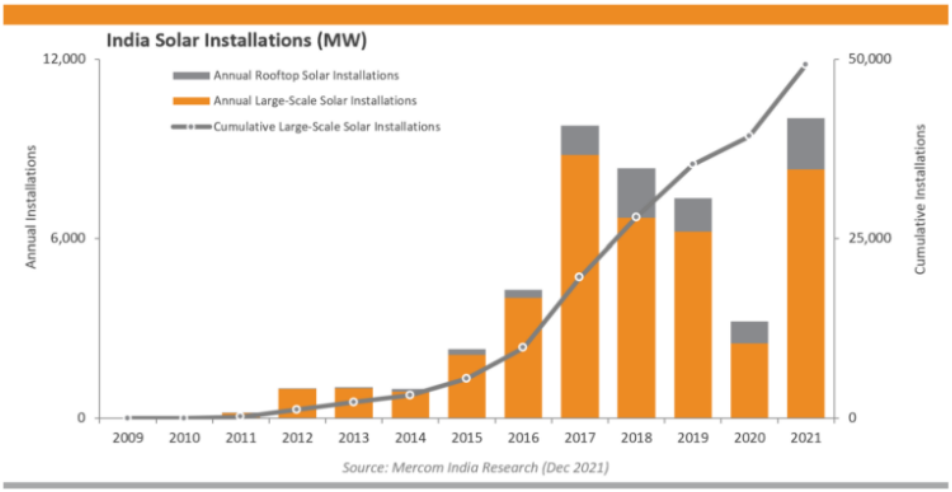
- Increasing electrification
- Higher penetration of cleaner fuels in the energy mix
- Accelerated adoption of energy efficient technologies
- And rising digitalization[40].

The Energy Advisor of the premier government think tank, (Niti Aayog), sees the Indian clean energy market opportunity at US$20 billion annually, following the adoption of the very ambitious targets at COP26.[41]

India's Solar Energy Performance in 2021

According to the latest findings of market research firm Mercom[42], India added 10GW of solar capacity in calendar year (CY) 2021, which was a 210% increase year-on-year (y-o-y) compared to CY2020, when just 3.2GW was installed. As the graph below indicates, during CY2021, large-scale solar projects accounted for 83% of installations with 8.3GW and saw an increase of 230% y-o-y. Rooftop PV installations made up the remaining 17%, adding 1.7GW which was a 138% spike y-o-y. Installation totals were likely boosted in 2021 because of a large backlog of projects that could not proceed in 2020 due to Covid-19 related lockdowns; the following year, in 2021, solar plant construction was declared an "essential service" and work was permitted to continue when other activities were at a standstill. Figure 1 below, prepared by Mercom India Research, shows the steep growth of cumulative solar installations since 2015.

Figure 1: The Growth of Solar Installations in India 2009-2021



Mercom (2021)[43] reports that India's installed renewable energy capacity, including large hydro projects, stood at 150.9GW, accounting for a share of 38.4% in the overall generation mix at the end of December 2021. Newly installed solar capacity in 2021 reached a new high, making up 62% of all power

[40] https://energy.economictimes.indiatimes.com/news/renewable/india-to-create-20-billion-renewable-energy-market-opportunity-annually-rajnath-ram-niti-aayog/89657147
[41] Ibid
[42] https://mercomindia.com/product/q4-2021-india-solar-market-update/ ibid
[43] Ibid

capacity installed in 2021. Solar now accounts for 12.4% of India's total installed power capacity of 390GW, and 32% of the total installed renewable capacity as of 2021.

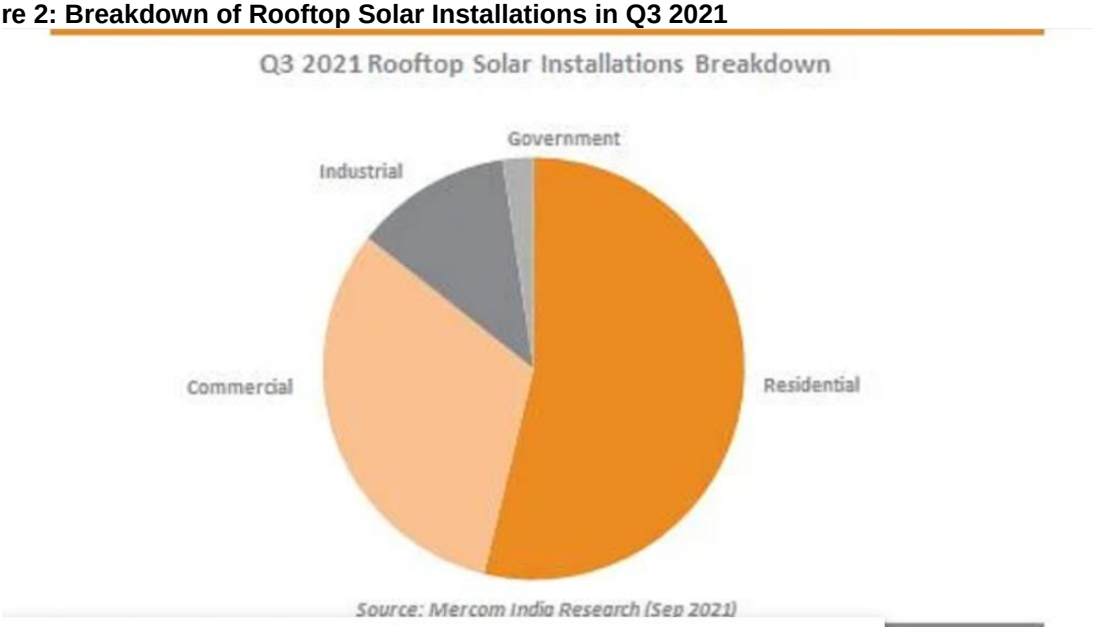
Highlights from Mercom's end-2021 Annual Solar Market Update are as follows:

- Solar installations of over 10GW in CY2021 were the highest ever recorded in India.
- Cumulative solar installed capacity in India was approximately 49GW at the end of Q4 2021.
- Rajasthan, Karnataka and Andhra Pradesh were the top three states for large-scale solar installations.
- Renewable energy sources accounted for 77% of total new power capacity added in 2021, a clear indication that the shift to clean energy has commenced in India.

Solid Growth in Decentralized (Rooftop) Solar

India added 1.3 GW of rooftop solar in the first nine months of 2021, a 202 per cent increase compared to same period last year. Installations are the highest ever recorded in the first nine months of the year. Figure 2 below, from Mercom (2021), shows the preponderance of residential rooftop installations due to very attractive policy incentives such as net metering, which is now only offered to residential customers (no longer to commercial, industrial and government buildings). Also, most states have attractive capital subsidies upfront which are only offered to residential customers.

Figure 2: Breakdown of Rooftop Solar Installations in Q3 2021

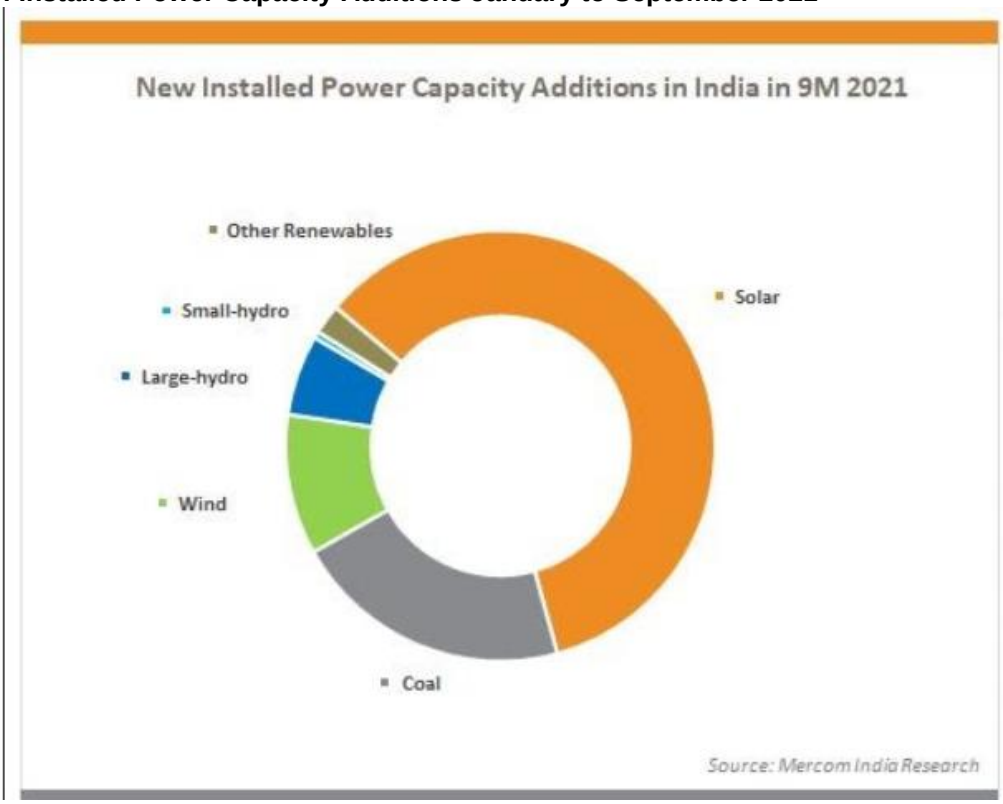


Rooftop Solar was initially embraced by large Commercial and Industrial (C&I) customers, and this helped to build a sound foundational eco-system for decentralized solar, that supported the growth of the sector. In earlier years when net metering was offered to all rooftop connections, the early movers were mainly commercial and industrial customers, since their cost savings were the greatest. Their savings were naturally higher because under the cross-subsidizing tariff structure prevailing in every state, C&I consumers pay the highest tariffs to the grid. Any ability to avoid the "artificially high" grid tariff would lead to high positive savings. Also, creditworthy C&I customers were the ones who first qualified for the limited commercial lending that was available when rooftop PV was still very new, and bankers were still unfamiliar with, and risk-averse about, the technology. The C&I market segment

helped to bring a rush of initial private investor interest (around 2017) into the nascent Indian rooftop solar market at a time when utility-scale solar margins were shrinking due to intense competition. Appendix Three provides a detailed discussion of learnings from the Residential Rooftop Solar segment in India.

Figure 3 shows the dominant presence of solar and the diminishing role of coal in the energy mix. Wind and Hydro capacity were also added in 2021. Figure 3 also confirms that there was also activity in other renewable energy markets in 2021, beyond solar PV—despite continued movement restrictions due to the Covid-19 pandemic.

Figure 3: Installed Power Capacity Additions January to September 2021



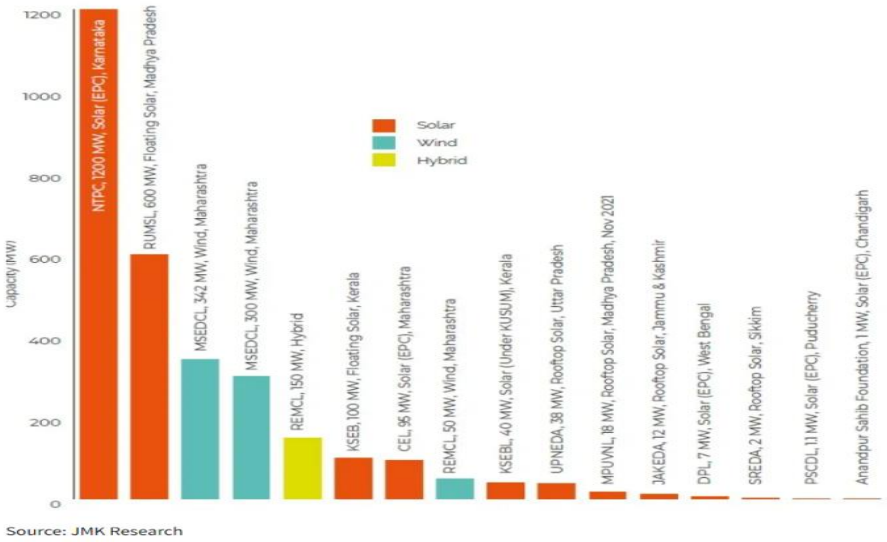
The Role of Public Enterprises

As noted earlier, government companies are also being "nudged" to do their part in meeting the national solar targets. Therefore, apart from private investors competing through tenders to build and own and operate large scale solar RE plants, there were also additional RE plants commissioned all over the country, by various public sector entities. These government-owned companies have been investing a part of their surplus earnings into solar PV capacity addition (instead of returning these funds as dividends to the Ministry of Finance). They are often at the forefront of commissioning the most innovative and hence risky tenders such as wind-solar hybrid, round the clock "firm power" (meaning the developer has to combine solar PV with a storage option and quote a price for dispatchable renewable power) and floating solar.

The following research by JMK Market Analytics[44] and Figure 4 below, shows the intense level of tendering activity for just the (randomly selected) month of November 2021:

- In November 2021, 17 new renewable energy (RE) tenders with a total capacity of 2,981 MW were issued. NTPC, the leading thermal power parastatal company issued a solar (EPC) tender of 1200 MW in Karnataka and the state Solar Park company of Madhya Pradesh, Rewa Ultra Mega Solar Ltd (RUMSL) floated 600 MW floating solar tender in Madhya Pradesh.
- In addition, the state electricity distribution company of Maharashtra State, MSEDCL, issued two wind tenders of 342 MW and 300 MW capacity in Maharashtra this month.
- Another public sector company, REMCL, issued a hybrid tender for supply of 150 MW of Round-the-Clock (RTC) Power[45] from grid-connected RE power projects, complemented with power from any other source or storage.

Figure 4: Renewable Energy Tenders issued in November 2021 for Solar (ground-mounted, rooftop and floating), as well as Wind and Solar-Wind Hybrid Installations



Source: JMK Research

Energy Efficiency

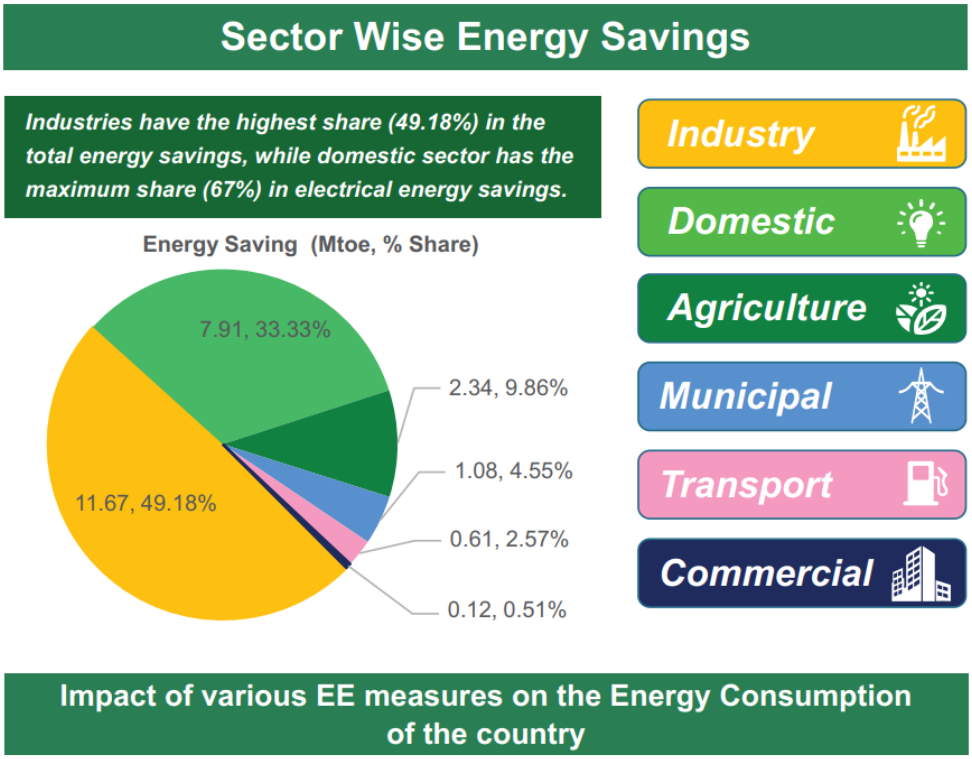
The Bureau of Energy Efficiency (BEE) [46] operating under the federal Ministry of Power, undertakes an annual study called Impact of Energy Efficiency Measures, to calculate sector-wise energy savings. This compares the actual energy consumption with the estimated value of what energy consumption would have been in the absence of intentional energy saving measures that were undertaken. Figure 5 below summarizes the findings for 2018-19.

[44] https://jmkresearch.com/renewable-sector-published-reports/monthly-renewable-sector-update-utility-scale-solar-wind/monthly-re-update-november-2021/ accessed on March 5th, 2022

[45] Round the Clock (RTC) power is an Indian innovation whereby the tendering authority places the burden of firming up intermittent power on the renewable energy developer. Bidders are asked to quote whatever source of storage they wish (pumped storage, flywheel, lithium-ion batteries etc) and quote a tariff for on-demand renewable energy. Price discovery has shown surprisingly competitive rates. Rates are likely to come down further still, as storage technologies gain economies of scale in India.

[46] https://www.beeindia.gov.in/sites/default/files/Booklet%20%28Rev-03%29_0.pdf

Figure 5[47]: 2018-19 Figures on Sector-Wise Savings Resulting from the Adoption of Energy Efficiency Measures



India has been very successful in pursuing energy efficiency, and has a relatively long tradition in this area since it passed the Energy Conservation Act in 2001. It has already demonstrated world leadership in lowering the cost of LED bulbs to reduce the energy consumption and cost of household lighting. Widespread use of LEDs also helps in cutting GHG emissions from decreased energy use and flattens evening peak demand, which in turn saves on the need for additional generation investment. As an offshoot of its success with the UJALA program that "crashed" the price of LEDs and made them affordable and accessible, India has also implemented the world's largest municipal street-lighting program by replacing incandescent bulbs with LEDs and saving money for municipalities on their electricity bills. The International Energy Agency (IEA) notes in a 2016 case study of UJALA[48]:

> "UJALA, the world's largest zero-subsidy LED bulb program for domestic consumers, is an extraordinary example of successful energy efficiency programs. UJALA is a market driven initiative, with strong policy support from the government. It is an example of a self-sustaining government initiative that has not only surpassed traditional benefits, like energy savings and reduced carbon emissions, but has also triggered large scale investment in the manufacturing of LED bulbs, generated employment and other macro benefits…

[47] ibid
[48] IEA, 2016 < https://eeslindia.org/img/uajala/pdf/UJALA_Case_Studies_1.pdf>

> UJALA has successfully distributed more than 100 million LED lamps across 120 cities, which has greatly impacted the LED market in India. EESL[49]'s LED bulk procurement has also contributed to the reduction in LED retail market prices from approximately 800 INR per LED bulb in 2012 to 200 INR per LED bulb in 2016 [and subsequently 70 INR (just under US$1) in 2022, all due to scale economies] – leading to one of the fastest LED price reductions in the world. This has helped improve acceptance and availability of LEDs in the Indian market. High quality has been a priority, backed by a three-year manufacturer's warranty. EESL's specifications, including the three-year warranty requirement, have ensured that the LED bulbs procured meet high quality standards with current failures at only 0.3%. This is helping build market confidence in the product."

It bears emphasizing that the LED price reduction in India happened with no government subsidy. It was achieved only through demand aggregation and EESL's credibility as a bulk purchaser, built on its ability (as an agency of the central Ministry of Power) to place very large orders by combining demand from participating states. This large market commitment in turn encouraged the entry of a handful of manufacturers and provided them with the confidence to set up large production facilities to meet the demand at scale. EESL plans to continue this demand aggregation strategy and extend the energy efficiency market to other products after its success with LED bulbs, and will likely extend its bulk purchasing drive into other areas such as pumps, smart meters, electric buses etc. Today in early 2022, the number of LED bulbs distributed under UJALA has reached 368 million, and the cost has come down by 85%. A recent report[50] notes that the UJALA program in seven years has saved 47,778 million units of electricity per annum. The UJALA program was launched by the Prime Minister in January 2015.

Challenges

There is no role model and no global precedent for undertaking across-the-board Climate Mitigation Action simultaneously with Action on Economic Development, Poverty Alleviation and Increasing Access to Energy, as well as Pursuit of all 17 Sustainable Development Goals (SDG). India's Climate Action Plan is unprecedented in terms of its scale and ambition, primarily because the country is trying to implement an energy transition while also growing the energy sector and per capita energy consumption, and trying to meet all of the 17 Sustainable Development Goals for at least 50% of the population (650 million people).

A successful clean energy transition rests on technologies which help to decouple economic growth from increased emissions. India is investing in R&D in order to avoid confronting a situation of having to pay premiums to access clean technology. India has a large pool of scientific manpower and a network of public sector, advanced technology and engineering institutes, and therefore it is possible to attempt such R&D.

India is also attempting to double its current GDP from $2.7 trillion to $5 trillion by 2025 (although this latter goal is likely to be delayed by the pandemic). At the same time, India has committed by 2030 to:

- Reduce the energy intensity of its economy by 40%;
- Cut emissions by 1 billion tons relative to 2005;

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[49] EESL refers to Energy Efficiency Services Ltd, and is a procurement and implementation agency under the federal Ministry of Power in India. EESL often partners (when invited) with state and local government agencies to provide hand-holding support to implement various initiatives such as LED bulb distribution, or replacing incandescent bulbs in millions of streetlights, or planning Electric Vehicle charging infrastructure, etc. Partnering with EESL often brings the advantage that EESL can aggregate demand and help vendors to achieve economies of scale, thereby lowering prices for all purchasing participants through bulk-buying.

[50] January 5, 2022 https://economictimes.indiatimes.com/industry/energy/power/govt-distributes-36-78-cr-leds-under-ujala-scheme/articleshow/88710534.cms?from=mdr accessed on March 19, 2022

- Install 500GW of renewable energy generation capacity;
- Meet up to half of its energy requirements from clean energy, by transforming its energy sector to phase down reliance on coal, and reach Net Zero by 2070.

The implication of these commitments, particularly emissions reduction of 1 billion tons by 2030, is that India should meet the challenges of undertaking all necessary technology investments and upgrades to integrate intermittent renewable energy into the transmission grid in order to send clean energy all over the country.

Clean Technology Transfer

There is a concern amongst developing countries, and very much so in India, regarding the cost and terms of clean technology transfer, and/or access to innovations that may emerge in developed countries R&D labs. These may include for example new techniques for Carbon Capture and Storage (CCS) or new energy storage cell chemistries or new low-carbon methods for steel and cement production.

The concern equally applies to how clean energy financing will be made available.[51] If clean energy technologies developed in rich-country R&D facilities are ultimately patented by private companies and transferred to the developing world at high prices (because market rates of return are charged for embedded Intellectual Property Rights (IPR) protection), then the costs of accessing such technologies will be very high. This is because the hardware cost will have a patent protection or licensing fee added to it, increasing the base cost, and this in turn will increase the size of the loan that must be taken to access that particular technology.

Developing countries are unlikely to agree to take on large and expensive commercial loans and further add to their foreign currency indebtedness, in order to do their part for a clean energy transition necessitated by the actions of others.

The experience of investment in utility-scale solar PV has shown that any clean technology which operates on "free fuel" (e.g sunshine or wind or biomass or discarded waste) is primarily an asset financing or technology hardware-financing issue. After acquiring the hardware and installing and commissioning it, there is minimal additional operating cost for the life of the plant (particularly for solar and wind farms). The loan terms on which the hardware/technology was acquired (i.e the interest rate and number of years allowed for principal repayment) are the single most important determinant for the "cost per kWh" at which the resultant energy can be sold. Appendix Two contains a detailed explanation of how loan terms directly translate into the cost per kilowatt-hour of clean energy. It shows how a country's access to a long term, low interest rate loan for investing in solar generation equipment will allow the country to price solar energy more affordably and thereby hasten its adoption by consumers, as they abandon fossil fuels.

Transmission Challenges

The Indian transmission network is currently the fifth largest in the world. Renewable energy resources (chiefly solar and wind) are not evenly distributed throughout the country. Hence high voltage and extra-high voltage transmission networks are being built by the national Transmission System Operator, PowerGrid Corporation. These "Green Corridor" investments are designed to deliver surplus renewable energy generation from the west and the south of the country, to the north and the east. One major achievement was the interconnection of all regional grids into one large national transmission network,

[51] The recent global experience with sharing of Covid-19 vaccines during the pandemic of 2020-2022 has been instructive for all developing countries.

which took place ahead of schedule, in December 2013. The transmission carrying capacity and the human resource capacity for better management and integration of renewable energy are now being expanded. In mid-2020 (despite pandemic disruptions) India was able to inaugurate a network of 12 Renewable Energy Management Centers[52] (REMC).

A GIZ report prepared for the Ministry of New and Renewable Energy notes[53]:

> "The electricity system in India faces several challenges as the energy demand is expected to grow significantly within the next decades while the domestic energy resources in terms of fossil fuels are limited. Variable generations from RE such as wind and solar plants together are posing significant technical difficulties of grid management. Gauging the future projections of higher share of renewables, it is imperative to have a good forecast and appropriate balancing action".

Financing Challenges

To date, nearly all climate mitigation investment efforts have been undertaken with domestic public and private investor resources, sovereign-guaranteed borrowing or external private commercial investment (foreign direct investment, FDI) and commercial loans or green bonds. The Green Climate Fund, with total cumulative resources of US$10 billion to date, was set up to fulfil the pledge made at COP15 in Copenhagen in December 2009[54]. But finance has been limited. In its own words:

> The Green Climate Fund (GCF) – a critical element of the historic Paris Agreement – is the world's largest climate fund, mandated to support developing countries raise and realise their Nationally Determined Contributions (NDCs) ambitions towards low emissions, climate-resilient pathways[55]**.** Only four Indian projects have received loans from the Green Climate Fund so far, in the amount of $314.8 million[56].

Technical Assistance and Capacity Building

Technical Assistance (TA) Partnerships, when they can be organized, are very useful for India's energy transition. TA projects deliver more cutting-edge international support on the ground. TA partnerships seem to deliver better value than awaiting financing from the elusive "$100 billion a year" international climate finance. In any case, the Paris pledges seem to be perennially overtaken by events that alter the priorities of so-called "Annex 1" parties to the Paris Agreement (first came the domestic fiscal stimulus in each country due to the pandemic, then came Russian gas shortages and then energy price spikes due to war, etc).

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[52] https://mnre.gov.in/img/documents/uploads/80f821f916274ab9b73ac8869a0fa619.pdf
[53] ibid
[54] In 2009, at the fifteenth conference of the parties (COP15) of the UN Climate Change Conference (UNFCCC) in Copenhagen, climate finance funding of $100 billion a year through the Green Climate Fund was agreed.
Climate finance is being delivered by Annex I countries of the UNFCCC agreement (referred to as developed countries by the UNFCCC, with high greenhouse gas emissions) to non-Annex I countries (referred to as developing countries).
The finance is to fund climate change mitigation, which are measures to reduce greenhouse emissions, and adaptation to climate change. Funding can come from public and private sources and be provided in different forms.
The $100bn commitments were reiterated at COP 16 in Cancun in 2010, and at COP21 in Paris in 2015, where it was agreed to extend the commitment to provide $100bn every year to 2025.
Final figures will not be available until 2022 but it's generally accepted that the 2020 goal has not been fully met.
(https://commonslibrary.parliament.uk/cop26-delivering-on-100-billion-climate-finance/#:~:text=Why%20climate%20finance%20matters,year%20by%202020%20was%20agreed.) accessed on March 5th, 2022
[55] https://www.greenclimate.fund/document/financing-climate-action#
[56] https://www.greenclimate.fund/countries/india accessed on March 5th, 2022

Capacity building for climate change is needed throughout India's vast government structures at three levels of government (central, state and local). States in particular, where people live and where the climate actions will be taken, require a lot of help with climate change which has become a bugbear and an extra responsibility added to an already long list of administrative tasks with not enough state employees to carry them out. Notable benefits from technical assistance partnerships particularly include those resulting from India's deep engagement with the German government's bilateral program on India's climate transition, as well as with the European Commission's "Strategic Partnership for Implementation of the Paris Agreement"[57] (SPIPA), and innovative engagements with the United Nations Industrial Development Organization (UNIDO) to build capacity in the Indian private sector.

Land as a major risk factor

How land allocations for RE investments are managed in the various states, will be a key issue on whether the buy-in for building large-scale renewable investments is sustained. There is a risk that future conflicts over land use could stymie the growth of the onshore RE sector as we know it. If that happens, it could move future renewables to other, non-land-based (and more expensive) technologies, such as off-shore wind and marine solar, for example.

For any available vacant government land, or even private land that is put up for sale or lease, there are likely to be numerous competing uses in a crowded country like India, some for economic goals and some for the pursuit of climate goals.

There are also afforestation and biodiversity protection goals which require land, not for building, but on the contrary, for re-wilding or protecting. Then there is also the need for land to build smart cities and sustainable housing, roads, bridges, water and sewage treatment plants, airports, seaports, cold-chains, organic farms, post-harvest warehouses, factories (including giga-factories to build hardware related to climate goals, such as solar panels and energy storage and electric vehicles). India needs all of these, in order to deliver the development schemes, plans and pledges that populate the websites of its numerous government Ministries. Then there are also land requirements for an entire range of other hard, physical infrastructure assets.

How to decide on the highest return for the many competing uses of a given area of scarce land, is merely one of many challenges that the government will face.

[57] https://www.international-climate-initiative.com/en/details/project/strategic-partnerships-for-the-implementation-of-the-paris-agreement-spipa-17_I_364-2993

4. The Conundrum: Decoupling Growth from Ever-Increasing GHG Emissions, and India's Two-Fold Challenge of Meeting Economic Development Goals and Climate Goals

Key Takeaways

- India faces a unique set of challenges as it seeks to forge a one-of-a-kind low carbon growth path through which to meet its development goals of pursuing SDGs and its ecological and climate goals to meet its national decarbonization and energy transition targets.
- India has to decarbonize while also building massive infrastructure, including smart megacities of the future, and deliver safe piped water supply and sanitation to hundreds of millions, deliver education and healthcare and new farming methods, cold chains for improved agro-processing and increased farm incomes, improved transportation, improved roads, bridges, flight connections, etc. There is no role model nor historical precedent for this, as 'higher emissions accompanying economic growth' has been the historical pattern of all rich countries up to now.
- India's unfolding climate action strategy seeks to *maximize energy efficiency* and simultaneously *increase the share of renewables*, thereby creating a path to *reducing the growth rate of emissions, then peaking, plateauing and decreasing emissions, and eventually achieving net zero*. India, through experimentation with these approaches, will need to find its own formula for *decoupling economic growth from ever-increasing GHG emissions*.

How will India thread the needle between taking climate-positive actions and also pursuing economic growth and increasing the standard of living of its population? The latter requires at least a doubling if not a tripling of average per capita energy consumption (today India's per capita consumption is just a quarter of the global average).

Ritchie (2021) notes that the average American consumes as much energy in a month as the average Indian consumes in a year[58]. Even if India's average per capita annual electricity consumption of 1,000kWh were to be hypothetically tripled, (which is neither realistic nor feasible due to a lack of funds and land availability), it would still be lower than the global average value of 4,400kWh electricity consumption per capita per annum.

India's unfolding strategy instead involves seeking ways to *maximize energy efficiency* and simultaneously *increase the share of renewables*, thereby creating a path to *reducing the growth rate of emissions, then peaking, plateauing and decreasing emissions, and eventually achieving net zero*. The Indian Ministry of Power website[59] states:

> "Government of India has undertaken a two-pronged approach to cater to the energy demand of its citizens while ensuring minimum growth in CO2 emissions, so that the global emissions do not lead to an irreversible damage to the earth system. On one hand, in the generation side, the Government is promoting greater use of renewable in the energy mix mainly through solar and wind and at the same time shifting towards supercritical[60] technologies for coal-based power plants. On the other side,

[58] Ritchie, H., November 30, 2021 "Global Comparison: How much energy do people consume?" < https://ourworldindata.org/per-capita-energy > see also the interactive map at this website (and note: pointing the cursor at any country on the map shows not only electricity use but overall energy used for transport, heating and cooking in addition to electricity)

[59] Ministry of Power, Government of India <https://powermin.gov.in/en/content/energy-efficiency > accessed on March 21, 2022

[60] This write-up explains how super-critical technologies allow less coal to be burned per hour, resulting in fewer GHG emissions, compared to sub-critical thermal coal technologies Myllyvirta, L, 22nd June 2017 "How much do Supercritical Plants Really Reduce Air Pollution?"< https://reneweconomy.com.au/how-much-do-ultra-supercritical-coal-plants-really-reduce-air-pollution-70678/> accessed on March 19, 2022

efforts are being made to efficiently use the energy in the demand side through various innovative policy measures under the overall ambit of Energy Conservation Act 2001.

India, through experimentation with these approaches, will need to find its own formula for *decoupling economic growth from ever-increasing GHG emissions*. There is no role model nor historical precedent for this, as 'higher emissions accompanying economic growth' has been the historical pattern of all rich countries up to now.

Rich OECD countries are at a different starting point in their exploration of ways to decouple emissions and growth, having met their economic development and per capita GDP goals. Many of them are at saturation point in terms of energy use, and in fact moving to energy efficient technologies that are reducing per capita consumption. Their economies are also no longer growing fast, and mostly down to the very low single digits. India on the other hand, still needs to grow at 8-9% a year in order to meet its employment generation and poverty alleviation targets, and attain the SDGs. However, India has already started its home-grown R&D in the quest for highly energy efficient, widely used appliances such as fans and pumps[61] etc. It has also put in place (over a decade ago) large incentive schemes for industries to be more energy efficient, in order to try and meet its economic growth targets without having to use as much energy (and electricity) as others did.

The economist Kate Raworth has developed the concept of Doughnut Economics, as visualized in Figure 6 below[62]. The outer boundary consists of nine planetary boundaries or environmental ceilings beyond which lie unacceptable environmental degradation and potential tipping points that threaten human civilization. The inner ring or social foundation identifies twelve social dimensions that Raworth took from the minimum standards of social wellbeing, internationally agreed to and set by the United Nations as the world's Sustainable Development Goals in 2015. In the innermost circle, however, Raworth finds evidence that here too we are globally falling short in meeting many basic needs. Between social foundations and ecological ceilings lies the environmentally safe and socially just space Raworth thinks we need to strive for if humanity is to thrive.

In Figure 7 below[63], Raworth illustrates where we are now as a global community. Raworth's key message is that we must pay attention to all the red areas and seek to reverse them. We must climb back onto the doughnut and remain on the solid part, between its two boundaries or edges. These represent the social foundation we need, and the ecological ceiling which can support it.

While India has not explicitly referred to the Doughnut Economy model in its official statements, the illustrations in Figures 6 and 7 provide a very good visual representation of what we have referred to as the conundrum that India is now tackling. This represents the exact challenges that India faces as it seeks to forge a one-of-a-kind low carbon growth path through which to meet its development goals of pursuing SDGs and its ecological and climate goals to meet its national decarbonization and energy transition targets.

[61] Kanchwala, H. January 2022, <https://www.bijlibachao.com/fans/bldc-fans-super-efficient-fans-in-india-market-analysis.html>
[62] Raworth, K. "Key Concepts: Doughnut Economics", https://library.uniteddiversity.coop/Transition_to_Co-operative_Commonwealth/103-Key%20concepts%3a%20Doughnut%20economics.pdf
[63] Raworth, K., Ibid

Figure 6: Living within Planetary Limits and Addressing Basic Needs—Doughnut Economics

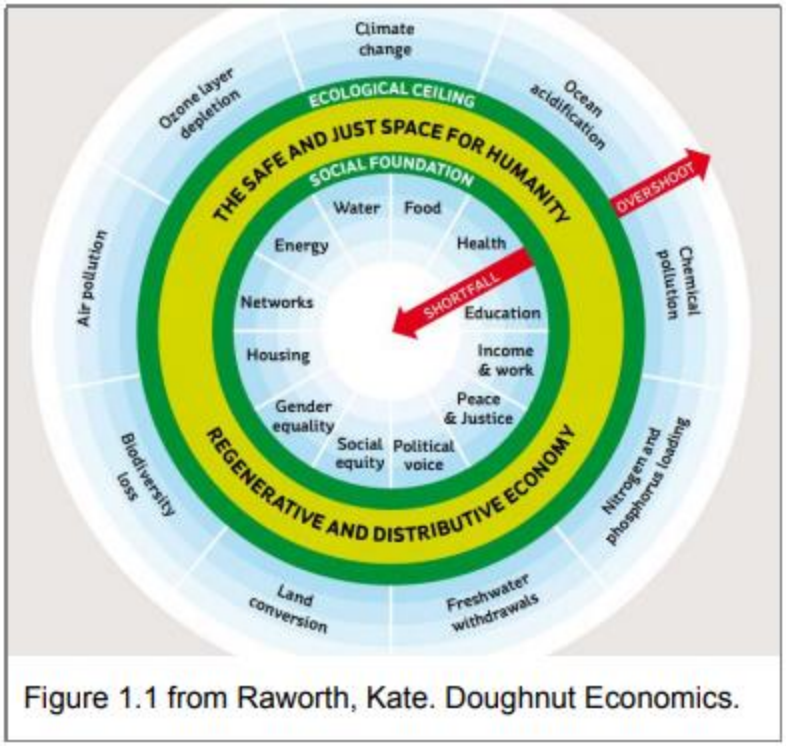


Figure 1.1 from Raworth, Kate. Doughnut Economics.

Figure 7: Shortfalls and Overshoots in a Doughnut Economy, and How to Restore Balance

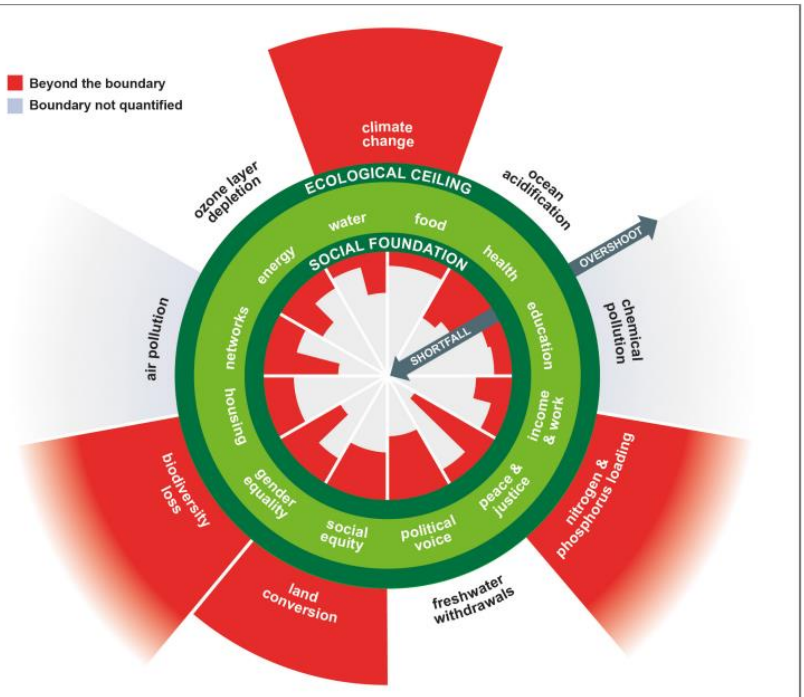


Figure 1.2 from Raworth, Kate. Doughnut Economics.

The type of outcome in Figure 7 above, is what India is trying to avoid. Through its climate strategy, it will need to shrink its own "red areas" of overshoot on the planetary boundaries, and through its SDG strategy it must restore and eliminate its shortfall on the social foundation (which has substantially increased due to the Covid 19 pandemic as will be discussed in detail in Part Four). The idea is to leave no one in the hole of the doughnut (the gap in the center, meaning that their SDGs are not met). The idea is also not to fall off the outer edge of the doughnut in terms of being out of line with available safe spaces for use of planetary resources. Raworth proposes the importance of managing economies so that everyone is sitting safely on the solid ring of the doughnut, neither falling into the hole nor falling outside and off the edge.

India, and other developing countries still have extensive economic development and poverty alleviation agendas. They need to build massive infrastructure, including smart megacities of the future, and deliver safe piped water supply and sanitation to hundreds of millions, deliver education and healthcare and new farming methods, cold chains for improved agro-processing and increased farm incomes, improved transportation, improved roads, bridges, flight connections, etc—*can this be done while also decarbonizing*?

As previously noted, this paper does not have the exact "yes or no" answer to that question, because India is still in the process of finding out how to tackle its two-pronged challenge:

- How to balance the competing budgetary and administrative/supervisory requirements of pursuing SDGs versus Climate Actions;
- How to decouple economic growth and GHG emissions.

Raj (2021)[64] puts it this way:

> "India is embroiled in one of the biggest public policy challenges of the 21st century to realise the twin goals which are virtually at loggerheads — economic development and climate change. India, being a lower-income country, is under tremendous pressure to lift millions of people out of poverty, whereas it is required to reduce dependence on greenhouse gas-emitting fossil fuels to address the challenge of climate change…. The rich produce more carbon footprint than the poor. Already, many sectors of the economy, regions and millions of poor people are affected by the increasing number of cyclones, high precipitation, floods, severe droughts, forest fires, acute shortage of drinking water, and destruction of social and economic infrastructure…. The pursuit of sustainable development is constrained by the challenge of mobilising financial resources for the mitigation of greenhouse gases and financing adaptation activities…

[64] Raj, K. November 2021, "Shadow of Poverty on India's Climate Goals" < https://www.tribuneindia.com/news/comment/shadow-of-poverty-on-indias-climate-goals-333942> accessed on March 19, 2022

5. Looking Ahead

Despite the huge progress in India's solar market, and the growing amount of solar PV installation each year, the overall RE installation progress is still somewhat behind schedule. To achieve the central government's ambitious target of 450 GW of renewable energy by 2030 (which is now raised to 500 GW by 2030, based on updated commitments at COP26), it would require annual renewable energy capacity installation of 36 GW, notes IEEFA[65]. In practice, the current annual record performance (admittedly under pandemic conditions) for solar installation is 10 GW, achieved in calendar year 2021.

IEEFA's hypothetical figure of 36 GW of additional renewables required per year to reach the 2030 target of 500 GW, would mean that India needs to add over three times the maximum annual capacity that has ever been commissioned in a calendar year up to now, i.e that was10 GW, or 10,000 MW, in 2021. Aspiring to a three-fold (actually 3.6-fold) average annual increase of installed capacity in turn would require further capital flows for renewables from both Indian and international investors. It is not clear whether those additional capital flows will be forthcoming, and if so, from where. This 3.6-fold annual increase may therefore not be practically feasible, due to a lack of funding, and the target year of 2030 may possibly have to be pushed back a little for India's 500 GW ambition. However, the 500 GW by 2030 target currently remains officially very much in place, and government tendering of large-scale solar capacity is continuing at a brisk pace.

We should also note that many RE contracts are currently already in the process of being awarded, or else are under construction. Such projects do not enter the official figures until they are commissioned, and it is therefore difficult to be accurate about how much additional capacity was "nearly completed" in 2021, over and above the 10 GW headline figure of capacity that came online.

As pandemic restrictions gradually ease, the market is certainly expecting a boom of additional solar capacity both from postponed projects and also from new projects, as well as innovative tendering announcements that are expected to come from the key central government agencies that commission large solar projects.

In fact, the Indian government has attracted the attention of other large developing countries (in a fine example of "South-South knowledge transfer" in this new and uncharted area) for its expertise in conducting very large, transparent and innovative e-auctions for renewable energy projects. These innovations include hybrid tenders (wind-solar auctions[66] for the same site), as well as two types of Round-the-Clock (or RTC) Power[67]. In one version of RTC the bidders are asked to offer quotes for delivery of combined renewable energy plus storage (the storage technology choice is left up to the bidder, but price discovery is underway for what it will cost to firm up intermittent renewables using storage). In the other version, bidders are asked to bundle (cheap) renewable and (more expensive) thermal power to guarantee 80% availability to the off-taker at all times, and also to ensure that at least 51% of the energy mix consists of renewables. Gulia and Garg (2021) provide a more detailed

[65] Garg, V., IEEFA, ibid

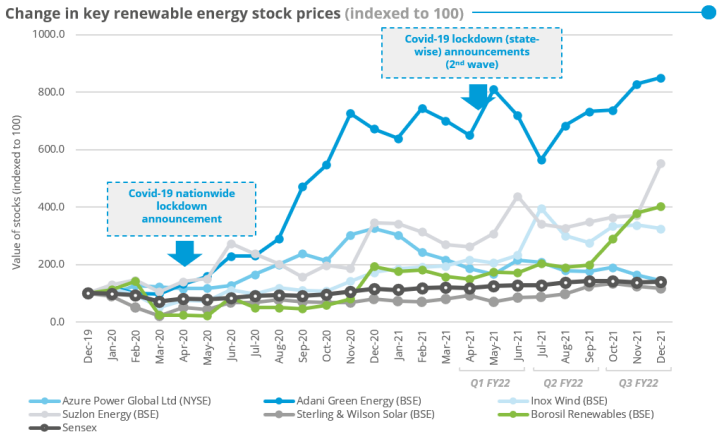
[66] Prateek, S., Mercom India, "India's First Mega Solar-Wind Hybrid Auction Sees Lowest Tariff of INR 2.67/kWh" < https://mercomindia.com/seci-solar-wind-hybrid-auction-results/#:~:text=SECI%20had%20initially%20tendered%202%2C500%20MW%20of%20ISTS-connected,bid%20capacity%20%281%2C050%20MW%29%2C%20which%20is%20840%20MW> accessed on March 21, 2022

[67] Economic Times, 21st Feb 2020 "Round the Clock Power Supply by bundling Renewable with Thermal Power: Draft Policy < https://economictimes.indiatimes.com/small-biz/productline/power-generation/round-the-clock-power-supply-by-bundling-renewable-with-thermal-power-draft-policy/articleshow/74238869.cms > accessed on March 21, 2022

explanation of this distinctly Indian innovation in tendering for more firm renewable energy at the lowest cost[68].

As noted earlier, a clear and unwavering policy commitment to renewables from the central government has created confidence for both investors and commercial lenders. Lenders are now more assured than they were in 2015-2017, that these high levels of renewable energy investment will find off-takers in the market through conducive government policies such as e.g Renewable Purchase Obligations (RPOs), or mandated purchase of a certain percentage of renewables amongst so called "obligated entities". [69] Lenders and equity investors therefore conclude that high levels of RE investments can be safely financed with commercial loans. In fact, the 175GW RE target set in 2014 has helped to propel India to a position amongst the top five ranked largest installed solar capacity countries[70] in the world today. Figure 8 below, shows the bullish market sentiment pushing up the value of renewable energy companies/investors in spite of a lackluster performance of other companies' stocks in late FY2022.

Figure 8: RE Finances--In contrast to a pandemic-affected, lackluster Indian share market in Q3 FY2022, most RE stocks continued to trend upwards[71] showing investor confidence



Source: Money Control.

India's stated ambition is to grow its US$2.7 trillion economy of today to US$5 trillion by FY2026, but this has undoubtedly been dealt a large setback by the Covid-19 pandemic that brought the country to a near-standstill twice in 2020 and 2021. Therefore, the new target date for a US$5 trillion economy may realistically be closer to 2030 than 2025. Can this giant leap be made while also shifting to renewables and reducing 1 billion tons of GHG emissions by 2030, as the Prime Minister announced at COP26?

On balance, given the remarkable growth of the sector in the five years before the Covid-19 pandemic, and the continued growth during 2020 and 2021, we believe there is reason for optimism that India's 2030 climate goals will be met on schedule or very close to schedule.

However, there are important areas which tend to receive less attention;

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[68] Gulia, J. and Vibhuti Garg, November 2021, JMK Research Analytics and IEEFA, "Understanding Round the Clock Tenders in India: The Current Context and the Way Forward" < https://ieefa.org/wp-content/uploads/2021/11/Understanding-Round-the-Clock-Tenders-in-India_November-2021.pdf >

[69] Ministry of New and Renewable Energy, Govt of India on Renewable Purchase Obligations: <https://rpo.gov.in/Home/Objective#:~:text=Under%20Section%2086(1)%20(,of%20the%20total%20consumption%20of > accessed March 21, 2022

[70] https://www.solarfeeds.com/mag/solar-energy-markets-in-the-world/ accessed on March 7th 2022

[71] CEEW-CEF Market Solutions Handbook Q3 2021-22, 10th February 2022, <https://cef.ceew.in/solutions-factory/market-handbook>

- Will enough climate adaptation investments be made in parallel, to protect the most vulnerable population groups from increasingly frequent, harsh and violent climate disasters? Adaptation investments increase resilience and seek to limit future hardship, particularly for vulnerable groups. However, because they generate no present cash-flows, they are mostly required to be grant funded (no loans, because no incremental cash flows from which to repay them). Where will the adaptation grant funds come from?
- Will the fragmented and cash-strapped state-owned electricity distribution sectors in enough of India's twenty-eight states be able to rise to the challenge of "electrify everything and use renewable energy", since that is part of the Indian government's dual strategy along with energy efficiency? Can the distribution sector's dilapidated networks efficiently absorb a sharply increased share of renewables?
- Will the competition for scarce land resources be managed well, between large scale renewables generation, versus large scale infrastructure development, versus nature and biodiversity conservation, versus simple habitation space requirements of a still-growing urban population? Can a backlash against land-hungry large scale renewable energy projects be avoided? What about water stress? Will that be managed and turned around so that various competing uses of water come back into balance?

India is poised to find out, as it moves forward in its climate action journey. India is very likely to find a way to get onto Kate Raworth's Doughnut that was discussed in Part Three of this paper, and it is highly likely that it will somehow manage to find a balance between the SDG imperatives as well as the decarbonization and other planetary boundary imperatives. Covid 19 has dealt a huge setback to this plan, in terms of massively expanding the red/no go areas in the Doughnut visualization, particularly inside the Social Foundation, i.e the pandemic has pushed over 70 million extra people back into the hole at the center, from which they had emerged due to previous economic growth efforts by the government. The greater worry is whether the SDGs will be met, whether the rate of poverty reduction will resume its pre-pandemic pace, and whether today's strong societal buy-in to renewable energy investments amongst the Indian public at large, will last. This is one of the areas that India will have to navigate carefully. All of the decision-making and trading off between Sustainable Development Goals and Climate Goals is to be achieved within a limited financial resource envelope in the form of the government budget

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Appendix I. The Eight Missions of the Indian National Action Plan on Climate Change (NAPCC)

The 2008 National Action Plan on Climate Change (NAPCC) focused on eight missions, which are as follows:

1. National Solar Mission: The NAPCC aims to promote the development and use of solar energy for power generation and other uses, with the ultimate objective of making solar competitive with fossil-based energy options. It also includes the establishment of a solar research center, increased international collaboration on technology development, strengthening of domestic manufacturing capacity, and increased government funding and international support.
2. National Mission for Enhanced Energy Efficiency: The NAPCC recommends mandating specific energy consumption decreases in large energy-consuming industries, with a system for companies to trade energy-saving certificates, financing for public–private partnerships to reduce energy consumption through demand-side management programs in the municipal, buildings, and agricultural sectors, and energy incentives, including reduced taxes on energy-efficient appliances.
3. National Mission on Sustainable Habitat: The NAPCC also aims at promoting energy efficiency as a core component of urban planning by extending the existing Energy Conservation Building Code, strengthening the enforcement of automotive fuel economy standards, and using pricing measures to encourage the purchase of efficient vehicles and incentives for the use of public transportation. The NAPCC also emphasizes on waste management and recycling.
4. National Water Mission: The NAPCC sets a goal of a 20% improvement in water use efficiency through pricing and other measures to deal with water scarcity as a result of climate change.
5. National Mission for Sustaining the Himalayan Ecosystem: This particular mission sets the goal to prevent melting of the Himalayan glaciers and to protect biodiversity in the Himalayan region.
6. Green India Mission: The NAPCC also aims at afforestation of 6 million hectares of degraded forest lands and expanding forest cover from 23 to 33% of India's territory.
7. National Mission for Sustainable Agriculture: The NAPCC aims to support climate adaptation in agriculture through the development of climate-resilient crops, expansion of weather insurance mechanisms, and agricultural practices.
8. National Mission on Strategic Knowledge for Climate Change: To gain a better understanding of climate science, impacts, and challenges, the plan envisions a new Climate Science Research Fund, improved climate modeling, and increased international collaboration. It also encourages private sector initiatives to develop adaptation and mitigation technologies through venture capital funds.

The NAPCC, as drafted in 2008, also describes other ongoing initiatives that are as follows:

1. Power generation: The government is mandating the retirement of inefficient coal-fired power plants and supporting the research and development of Integrated Gasification Combined Cycle IGCC and supercritical technologies.
2. Renewable energy: Under the Electricity Act 2003 and the National Tariff Policy 2006, the central and the state electricity regulatory commissions must purchase a certain percentage of grid-based power from renewable sources.
3. Energy efficiency: Under the Energy Conservation Act 2001, large energy-consuming industries are required to undertake energy audits and an energy-labeling program for appliances has been introduced.

4. Proposals for health sector: The proposed program comprises two main components, namely provision of enhanced public health care services and assessment of increased burden of diseases due to climate change.
5. Implementation: Ministries with lead responsibility for each of the missions are directed to develop objectives, implementation strategies, timelines, and monitoring and evaluation criteria to be submitted to the Prime Minister's Council on Climate Change. The Council will also be responsible for periodically reviewing and reporting on each mission's progress. To be able to quantify progress, appropriate indicators and methodologies will be developed to assess both avoided emissions and adaptation benefits.

Appendix II. Affordable Credit Is Essential for the Successful Adoption of RE Technologies

How Do Clean Technology Loan Terms Directly Translate into the Cost per kWh of Clean Energy? Most clean technology projects are financed under a non-recourse project finance arrangement by commercial lenders. This simply means that the project is ring-fenced in a special purpose vehicle (SPV), and all loan repayments are limited to the cash flows generated by the project. The project developer may have a huge balance sheet related to other businesses, but in non-recourse financing the lender does not have access to those funds if the project runs into repayment difficulties.

Project developers and investors in a clean energy generation asset (e.g a solar park) face the following costs: they must provide an up-front equity contribution (down payment) of around 20% of the project cost; this will qualify them for a loan of around 80% of the project cost; then they must also have funds to pay for some minor Operations and Maintenance (O&M) expenses e.g for cleaning dust, bird droppings etc on the panels to increase generation efficiency and energy output available for sale; trimming the vegetation under the panels; security guard costs etc. There is no fuel cost! (This is the biggest contrast with fossil fuel plants, where it is the fuel cost that causes price volatility of the end unit of energy generated).

The solar investor/project developer will forecast the number of units of energy to be sold from his plant every month (seasonally adjusted). The units must be priced so that the corresponding sales revenues (price per unit x quantity of units sold) fully cover all of the investor's costs. To recap, these costs are (i) the financial return required to be paid to the equity contributors who provided the down-payment that unlocked the commercial loan; (ii) the debt service payment required by the lender on the outstanding loan amount; (iii) the wage bill for the O&M employees; and (iv) any residual amount that can be put into a rainy-day fund or saved as surplus funds for an emergency.

The solar developer is operating in a competitive environment and cannot charge any amount he wants per unit of solar energy. Therefore, the price at which he sells each unit of solar energy will be lower for those developers who have lower monthly costs to be covered from the sales revenues. The two biggest elements are the debt service cost and the return on equity. The return on equity is more or less uniform for a given asset class (in this case solar parks; it started at 20% return when the asset was seen as highly risky and untested, and has now come down to 12-15% as investor comfort levels have increased). The O&M costs are also quite low in developing countries with low unskilled labour costs. The key difference then lies in the debt service cost which becomes the single largest cost that must be recovered through sales of solar energy from the plant. The solar energy units will primarily be priced to recover the sum of payments that are owed to the commercial lender (and also some extra markup to cover the additional amounts required to reimburse equity holders and wage employees).

Equity holders take higher risks than others, and therefore they know that they may not receive any payment in some months (e.g when there is a month of cloudy days and generation is very low, therefore sales revenues are also very low). The commercial lender is always paid before the equity holder (this is known as being "senior" in the payment queue). This is why equity holders' required returns are much higher than the commercial lender; they are paid last but they want the most, regardless of when that payment comes after others are paid and dismissed. The commercial lender knows that he will receive a fixed contractual payment every month regardless of whether the market is booming or slumping, or whether the sun is shining enough or not. The senior lender's risk is much less. If in a given month there are too few solar sales revenues to cover everyone, the senior lender knows that he is still likely to receive his share because of his preferred position at the front of the payment queue. Some lenders are willing to put the loan at the solar developer's disposal for a long period and receive principal repayments gradually over many years. Other lenders perceive a high risk to the project, the market or the developer, and demand to be repaid in full after only five or ten years. This means that the monthly debt service payment will contain a high amount of principal repayment, in addition to the interest payment on the un-repaid principal balance.

Here is a numerical example to illustrate:

Every loan for purchasing clean technology (let us assume a 200MW solar PV plant in this case) gives rise to a particular, customized stream of debt service payments to be made by the borrower. This depends on the principal amount of the loan (which is usually 80% of the cost of the hardware, since the borrower must put in 20% of his own funds as equity). To illustrate with round numbers, let us assume that the 200MW solar plant costs US$200 million to be installed and ready for commissioning. Therefore, the loan amount will be $160 million (80% of $200m), and the down payment or owner's equity is $40m. Suppose the interest rate on the $160m loan is 10% and the equity providers are looking for a return on equity of 20% on the $40m. To simplify the example, we can make the assumption that there are two identical solar parks next to each other. Both have identical loan amounts of $160m, each with an interest rate of 10%, but Solar Park A has a 10-year loan (meaning the $160 million must be repaid or amortized over 10 years, i.e at $16m a year), and Solar Park B has a more concessional, twenty-year loan, meaning the $160 million can be repaid over 20 years at $8m a year). The money that has to come out of annual solar energy sales from each Solar Park, has to cover the interest cost, the principal repayment obligation, the return on equity demanded by the providers of the $40m down payment that was required to obtain the loan, as well as some limited O&M costs for panel cleaning, watchman services, basic inspection etc. The two parks are identical in every way except for Park B having an annual principal repayment of $8m compared to Park A having an annual principal repayment of $16m. After year 10, Park A will be debt-free while Park B will still be repaying its loan at a steady pace.

Whoever takes the loan for financing investment of the clean technology hardware, has to finance their debt service payments to the lender, out of the revenues earned by selling clean energy units. If the debt service payments are high (because the loan is short-term and expensive), then the units of clean energy will be sold at a high price in order to channel a part of the sales revenues back to the lender. If the debt service payments are low and long-term, then clean energy units can be sold affordably and more easily displace fossil-fuel powered electricity because it creates cost savings for users.

Appendix III. Learnings from India's Rooftop PV Sector

The Residential Rooftop Solar Segment Grew After Discoms Moved Quickly to Limit the Attractiveness of Rooftop Solar to their Lucrative C&I customer segment. Discoms were required to give individual approvals for any customer who wished to connect an installed Rooftop Solar PV system to the distribution network. They were most reluctant to give speedy approval for their best customers, who were the commercial and industrial (C&I customer segement) to connect. Yet C&I stood to gain the most by investing in rooftop PV and avoiding the highly skewed, cross subsidizing tariff structure which meant that they had to pay far more than the cost of service incurred for the discom to serve them.

Financially strapped discoms petitioned their respective state electricity regulators (around 2019) to put an end to incentives such as net metering which made rooftop solar attractive for high-tariff customers. Discoms felt disadvantaged at losing revenues to Rooftop Solar from their high-paying Commercial and Industrial (C&I) customers[72] and hence wanted to reduce the potential C&I savings that could come from investing in rooftop PV, thus making rooftop PV less attractive for their best customers.

Interestingly, residential tariffs have always been less lucrative for discoms, because residential customers (who represent another voter group, like agricultural consumers) are charged electricity tariffs below the cost of service. Since the discom still does not recover the full cost of service from residential consumers in many states, it loses money with every unit supplied to this category. Hence no tears are shed by discoms if residential customers want to find alternatives to the discom, such as rooftop PV panels.

Lemonade out of Lemons—Allowing Net Metering Benefits to Remain in Place for a Given Market Segment of Discom Customers, Resulted in a Win-Win Outcome in some electricity markets in India. Some advanced Indian discoms which had the benefit of granular customer data because they had invested in advanced metering[73], realized that they would not mind "losing" part of the (insufficient) revenues from the unprofitable residential customer group.

In a few cases, such as in the privatized Delhi discoms, they actually encouraged residential consumers to switch over to Rooftop PV. This would help to limit the discoms' losses, by reducing the number of "loss-making" units of electricity sold to residential customers. In fact, the greater the numbers of small and loss-making residential/domestic consumers shifting over to rooftop PV, the better for discom finances, most likely!

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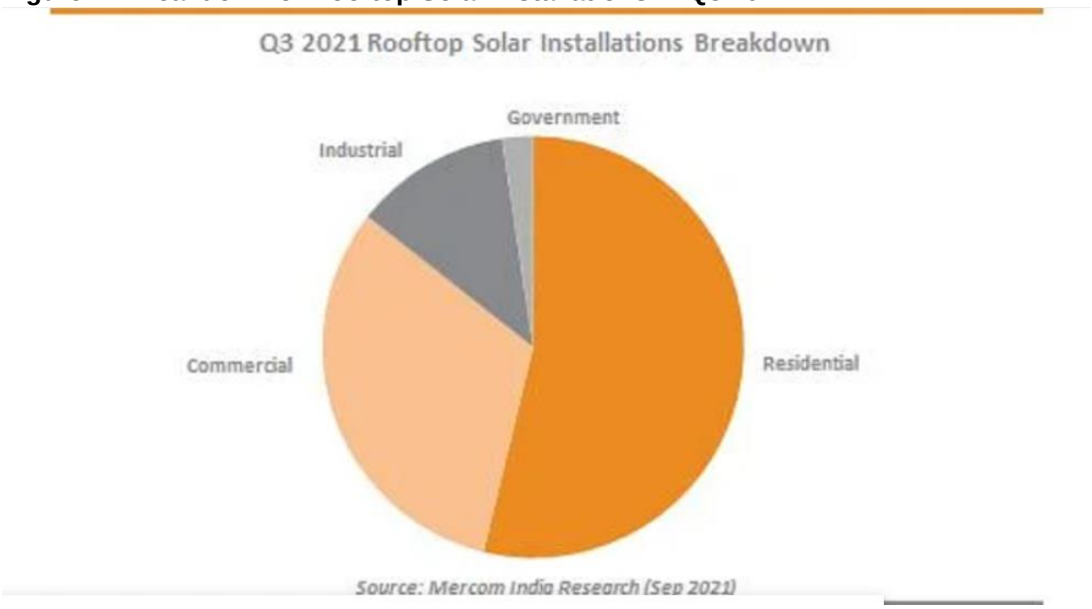
[72] The Indian tariff structure is State-specific, i.e every state sets its own electricity tariffs through its own electricity regulator. However, most states follow a similar pattern across different customer groups: they offer free or near-free power to agricultural customers for operating their pumps at the field, through un-metered connections. They charge residential customers a tariff that is below the cost of serving them. These two tariff categories are cross-subsidized by the Commercial and Industrial (C&I) segment, that faces tariffs much higher than the cost of service. This is why C&I customers are constantly looking for alternatives to grid power, where the high tariffs make their product or service uncompetitive. Discoms see the reliable revenues from C&I as their financial lifeline and are equally determined to block C&I escape routes from buying grid power.

[73] Kuldeep, Neeraj, Kumaresh Ramesh, Akanksha Tyagi, and Selna Saji. 2019. Valuing Grid-connected Rooftop Solar: A Framework to Assess Costs and Benefits to Discoms. New Delhi: Council on Energy, Environment and Water < https://www.bsesdelhi.com/documents/55701/3672243/Valuing-summary.pdf >

This fact possibly explains discoms' tolerance of continued residential net metering as the "lesser of two evils", because net metering is the carrot to convince residential customers to make the investment in rooftop PV[74].

The discoms and regulators had also initially tried to limit net metering to only 10kW installations (meaning only small residential customers), but there was a furor from the rooftop installation companies that this would put them out of business, so the restriction was later lifted.

Figure A: Breakdown of Rooftop Solar Installations in Q3 2021[75]



The results are clearly visible in Figure A, which shows the residential segment as occupying a large share of total Rooftop PV. Residential rooftop solar was previously insignificant, but in 2021 it had pushed aside the commercial and industrial segment that originally pioneered the rooftop PV segment in India from 2016-2019. By 2021, residential rooftop was seen to dominate the rooftop solar space.

Two reasons explain this: first the pandemic in 2020 and 2021 which gutted the C&I sector. It lost its customers, was forced to close premises, and had to lay off workers. There was no surplus cash to invest in rooftop PV for most of the segment. The second factor is that around 2019, many state electricity regulators (at the instigation of discoms) started to remove the net metering incentives which were the key driver of cost savings from investing in rooftop solar PV.

This dramatic shift in customer segments dominating rooftop PV underlines the importance of net metering as the most attractive incentive to promote decentralized solar. Discoms and their sympathetic state electricity regulatory commissions essentially removed the most attractive "carrot" (net metering) from C&I in order to limit grid-defection from the only lucrative customer segment that discoms have, which is C&I.

[75] Mercom India ibid

To conclude this point: a very good rooftop eco-system had previously been built in India (2016-2019), courtesy of the early movers in the C&I segment, who greatly benefited from investing in rooftop PV with net metering.[76] Damani (2020) notes:

> In 2019, the state government of Uttar Pradesh, Karnataka and Tamil Nadu withdrew their net-metering policies. The impact of the policy withdrawal has already been evident with a drop in rooftop solar installations across these states. More states are likely to follow suit. The final nail in the coffin seems to be the Draft law for the rights of electricity consumers. The draft provides for net-metering only with loads up to 5 kW and gross-metering for loads above 5 kW. Such a draft, if made into law, will encourage states to abolish net-metering. As a result, installation in more than 80% of the C&I market would become unviable until battery storage costs come down to INR 2 per kWh.

When C&I exited the rooftop segment, the robust eco-system that had grown to serve their needs, was later inherited by the residential rooftop PV customer segment. The residential segment was not attractive to market players for building as robust an ecosystem. Had they come first, (in other words if net metering policies had started out where they are at present) it is unlikely that the sophisticated eco-system and multiple business models that exist today in the rooftop PV system in India, would have been in place.

[76] Damani, A. Rooftop Solar Market in 2020, November 6, 2020, PV Magazine https://www.pv-magazine-india.com/2020/11/06/rooftop-solar-market-in-2020/