India's fast-expanding renewable energy sector - what are the ongoing developments and what does the future hold?

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A critical input for human well-being and for supporting productive economic activities is the reliable and adequate access to affordable energy. This is especially crucial for India as it addresses the various developmental challenges it faces. India's per-capita energy consumption was about 570 kgoe (kilograms of oil equivalent) in 2016, which was about one-third the global average of about 1780 kgoe and nearly one-fourth the Chinese per capita consumption of 2273 kgoe. The picture is nearly identical even for per-capita electricity use, with India standing at 1131 kWh/capita in 2017 compared to 3362 kWh and 4713 kWh for the world average and for China respectively. This energy poverty is being addressed by various central and state govt. initiatives and it is expected that energy demand would increase significantly in the coming years. This is important since a small increase in per-capita modern energy consumption correlates to a significant improvement in Human Development Index (HDI) levels for countries with low development indices such as India.

However, energy use contributed ~ 83% of India's Green House Gas (GHG) emissions in 2013 with this share increasing over time. With its long coastline, rainfall dependent agriculture and glacial fed rivers, India is also highly vulnerable to the impacts of climate change, and workable solutions to this global problem are therefore in India's interest. While India has recognized the need to mitigate climate change, it has also reserved its right to increase its consumption of modern energy for its development needs. As a result, India has resisted taking on absolute GHG emission restrictions and instead adopted *"measures that promote our development objectives while also yielding co-benefits for addressing climate change effectively"* as part of the National Action Plan on Climate Change (NAPCC). This views climate change mitigation as one among many objectives to strive for, along with others such as employment generation, economic growth, improved well-being of its citizens, and better local environment. This approach, which focuses on decreasing the carbon intensity of future economic growth, informs India's international pledges. India's pledge at Copenhagen in 2009 stated that it would voluntarily reduce its emissions intensity of GDP by 20-25% by 2020 compared to the 2005 levels. Under its Nationally Determined Contribution (NDC) to the 2015 Paris Agreement, India's 2030 commitments are to reduce the emissions intensity of its GDP by 33 to 35% compared to 2005 levels. This corresponds to roughly continuing the 16% reduction in carbon intensity already realised from 2005 to 2016. The NDC also included a pledge to achieve about 40% cumulative installed electricity capacity from non-fossil-fuel based sources.

Therefore, India needs a comprehensive approach towards it energy future given the multiple imperatives of universal and affordable energy access, energy security, limited fossil fuels reserves and their socio-environmental impacts, local as well as global. The United Nation's Sustainable Development Goals (SDGs) clearly law down the global vision for energy – universal access to affordable, reliable and sustainable energy. Therefore, renewable energy is a critical foundational element of that vision and shifting to a less carbon-intensive energy mix over time is imperative for India's contribution to global climate change mitigation.

With its vast potential resources and every-falling costs, renewables (esp. large –scale wind and solar PV) have been finally transformed into a serious mainstream electricity supply option. It is no longer seen as merely an answer to the environmental problems created from conventional energy use, but a critical element to enhancing the country's energy security and improving its macro-economic situation by reducing energy imports and thus minimizing its current account deficit. Absence of fuels (for wind and solar PV), low gestation periods (~1.5-2 years) and minimal marginal costs make them amenable to long term fixed price contracts, thus reducing electricity price volatility and reducing traditional financial risks. All the above factors have contributed to a strong policy and regulatory framework supported by the central and state governments for the rapid deployment of renewable energy.

Buoyed by this facilitating framework, renewable energy based electricity generation capacity has seen a strong annual growth of 20% over the last 15 years, with total installed renewable energy capacity at 70 GW (34 GW wind and 22 GW solar) or 20% of total installed capacity as of May 2018. This does not include the conventional large hydropower capacity of 45 GW. If one were to include it, as is the norm across the world, the share of renewables in the generation capacity rises to 33.5%. In terms of electricity generation, renewables contributed 102 billion kWh (7.8%) to India's total generation in 2017-18. Again, if one were to include generation from large hydropower of 126 billion kWh, the share of renewable energy rises to 17.5%.

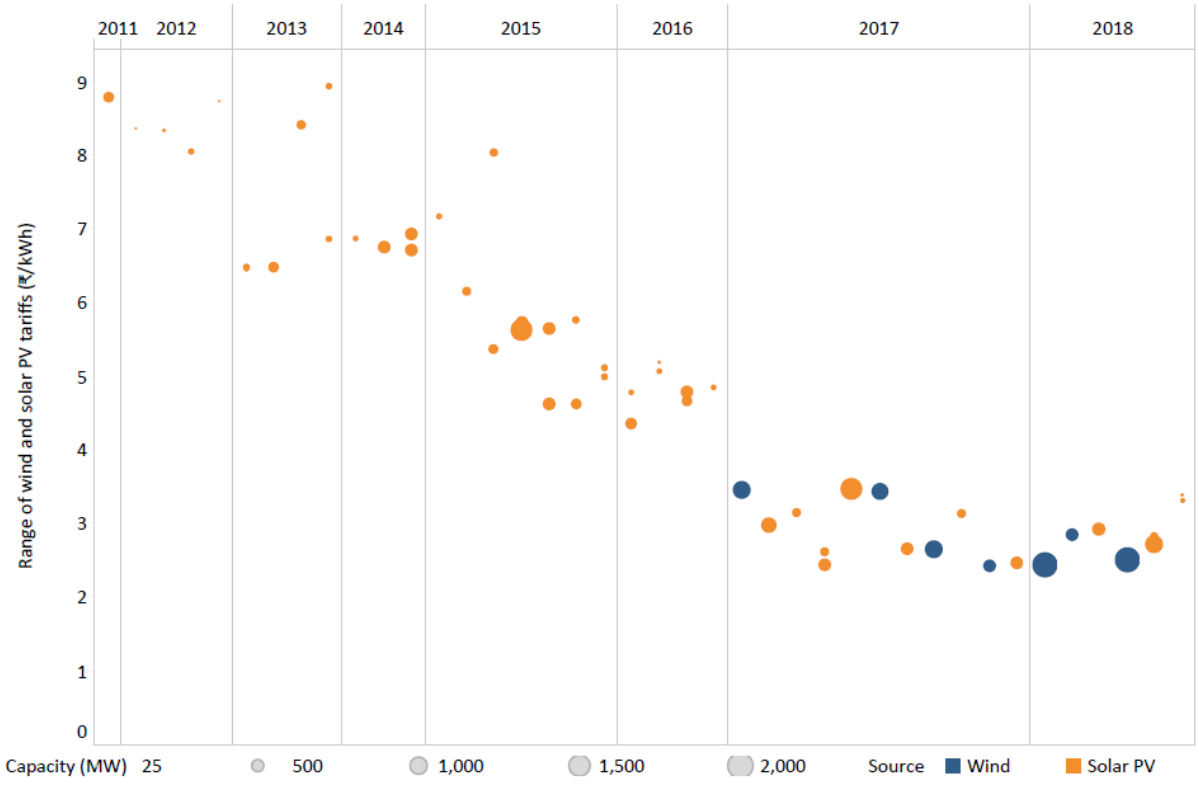
In 2015, India announced an ambitious target of 175 GW (100 GW solar + 60 GW wind) of renewable capacity by 2022, which would contribute just over 20% to total electricity generation. Auctions for solar and wind power in 2017 have discovered record low prices of ₹ 2.44/kWh and ₹ 2.43/kWh (CNY 0.24/kWh) respectively for solar PV and wind respectively. These are significantly lower than the 2018 feed-in-tariffs for solar PV in China, which range from CNY 0.55-0.75/kWh depending on the solar resource. This underscores the price-competitiveness of renewable energy (**see Figure 1**), especially when contrasted with new coal-fired capacity being contracted in the price range of ₹ 4-5/kWh (CNY 0.39-0.48/kWh). Note that these prices of wind and solar power only reflect their direct generation costs, and do not value its other benefits in terms of minimal environmental externalities, enhanced energy security, low gestation periods, and low price volatility. Being a variable source of energy, procuring renewable energy (especially wind and solar) potentially entails higher system-integration costs (especially for balancing), which need to be factored in for comparing its price with that of any baseload capacity like coal. However, a recent study by Central Electricity Authority in India found that "*even after including the financial implication on account of variable renewable generation, it would still be cheaper in the future to set up renewable generation capacity, as compared to coal-based capacity*". Therefore, generation prices are not going to be a hurdle for increased adoption of renewable energy in India.

A large part of the 100 GW solar target involves distributed generation. Specifically, 40 GW has been earmarked for rooftop solar projects, which are expected to be set up by industrial, commercial and residential consumers with available roof space. Consumers whose electricity tariffs are higher than the cost of generation from rooftop solar power (~ Rs 5-6/kWh, i.e. CNY 0.48-0.58/kWh) will find it economical to deploy such systems and reduce their electricity bills. This is in part due to 'net metering' which is a billing mechanism that credits solar energy system owners for the electricity they feed into the grid. For example, if a residential customer has a PV system on the home's rooftop, it may generate more electricity than the home uses during daylight hours. If the home is net-metered, the electricity meter will run backwards to provide a credit against what electricity is consumed at night or other

periods where the home's electricity use exceeds the system's output. Customers are only billed for their "net" energy use." As of 2018, more than half the sales of many distribution utilities can cost-effectively switch to rooftop solar. Further, the GoI offers a 30% capital subsidy for residential consumers for system sizes < 5 kW. However, progress under this segment has been much slower than anticipated (with only ~ 2 GW installed till date), mainly due to operational and procedural issues around net-metering and subsidy disbursal rules.

There is now little doubt that renewables would form the foundation of the future of India's electricity sector in particular and energy sector in general. The drastically falling prices of wind and solar power and ever-increasing capacity have compelled even ardent skeptics to acknowledge that renewable energy will play a major role in the future. However, the pace of this transition will depend on how the specific technical and regulatory challenges associated with renewables are handled. The major challenge that now remains is of reliable and cost-effective grid integration, which requires state-of-the-art modeling studies to understand the additional stress and complexity on system planning and operations due to renewables. It also requires a framework for greater cooperation across states and to equitably distribute the additional costs (if any) of grid integration among the various stakeholders. A crucial variable that would determine the future trajectory of renewables is the development of technology and the regulatory regime around electricity storage, as this can greatly help eliminate the intermittency associated with renewables.

Figure 1: Trends in solar PV and wind power tariffs discovered through competitive bidding in India (2010-2018)



Source: Prayas (Energy Group) compilation from various sources. For more such data on the Indian renewable energy sector, please see the Prayas (Energy Group's) Data Portal.

Recent developments

Ambitious deployment plans till 2030: The low costs of renewable energy coupled with its various other benefits have now nudged policy makers towards envisaging significantly higher shares of renewable energy in the medium term. Recently, the Ministry of Power has issued guidelines to the state electricity regulators to fix the minimum renewable energy procurement targets or purchase obligations (RPO) at 21% by 2022 (with an equal focus on solar-10.5% and non-solar (mainly wind) at 10.5%. The Minister of New and Renewable Energy in recent statements even evinced confidence that the country will not only meet the 175 GW target but may surpass it and may reach 225 GW by 2022. He further added that the share of renewables may further increase to 55% by 2030 (500 GW) and hence there are potential plans to bid out 40 GW of capacity (30 GW solar + 10 GW wind) every year from now onwards till 2028. Various new policies for offshore wind power, solar-wind hybrids and solar parks coupled with incentives such as waivers in the inter-state transmission charges and concessions in open access (third party sale) charges for renewable energy projects and streamlining of rules around captive (self-consumption) projects and grid connectivity is further accelerating the deployment of large scale renewables.

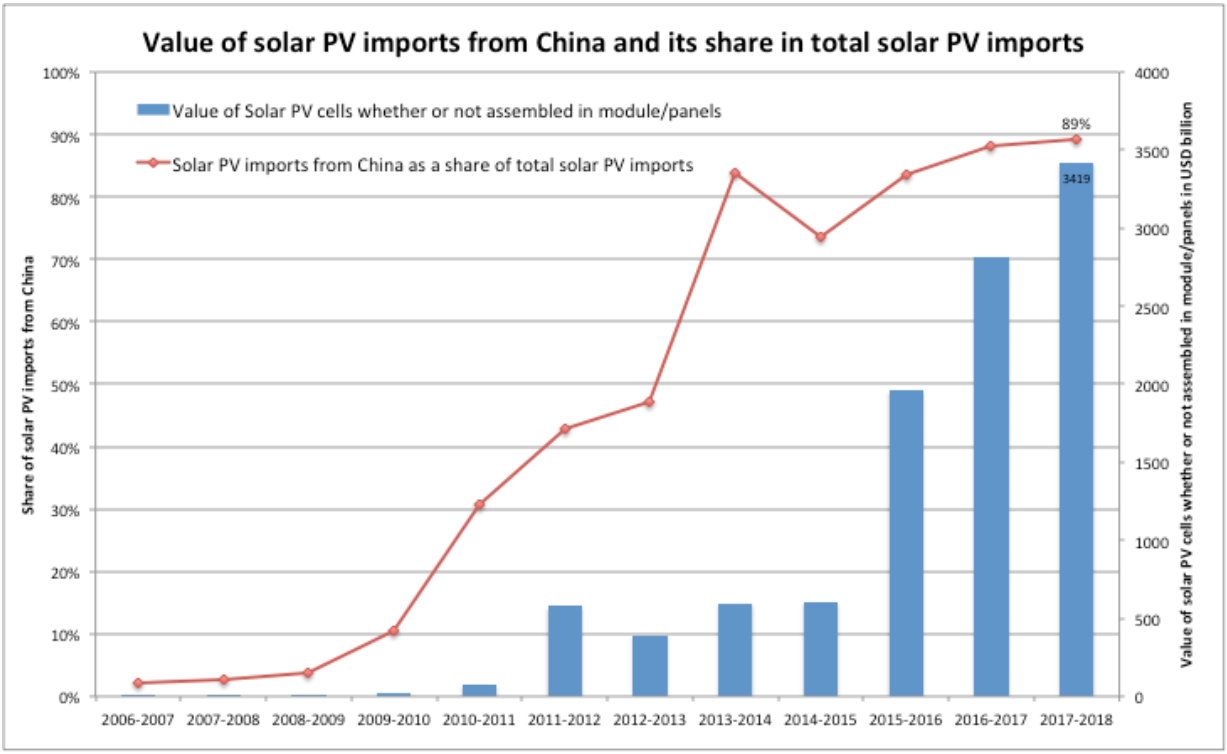
Solar energy in agriculture: A new and emerging part of the distributed solar program is its use in the agriculture sector for powering irrigation pump-sets. For areas with no/poor access to grid electricity, the use of solar-PV pumps is being encouraged with 30% capital subsidies and close to 1,75,000 such pumps have been deployed by March, 2018. Going ahead, the Ministry has proposed an ambitious solar PV target of 28 GW for agriculture consisting of 10 GW of grid connected solar power plants with capacity of 0.5 – 2 MW and 2.85 million solar pumps. The entire scheme for agriculture may need a huge capital support of close to 22 USD billion (CNY 139 billion).

Clean transportation: With regard to transportation, a significant push towards electrification is going to be the key towards reducing emissions and import dependency with 100% electrification of railways, setting up of metros in major cities along with electrification of vehicles including buses, cars, two and three wheelers being planned in the long run. A National Energy Storage Mission on the lines of the National Solar Mission is also in the offing. While a significant element of this mission would be EVs, it also includes the use of storage for various applications of renewable energy grid integration. Additionally, the Govt. of India recently approved of a national biofuels policy, which brings focus on second-generation biofuels and has earmarked Rs 5000 crore (CNY 4.8 billion) as viability gap funding for setting up ethanol bio-refineries over the next six years. The policy aims to reduce import dependency while reducing CO_2 emissions at the same time. For 2017-18, ethanol supply was roughly 1.5 billion litres, saving Rs 4000 crore (CNY 3.8 billion) in foreign exchange and avoiding emissions of 3 million tonnes of CO_2.

Renewable energy manufacturing: In addition to deploying renewables, the Govt. is now focusing attention on manufacturing. While India has significant manufacturing base of close to 10 GW/year of wind turbines, it relies significantly on imports of solar PV panels. **Figure 2** shows the value of solar PV

imports from China over the last ten years. There has been close to a 100% annual growth in the value of solar PV imports from China in this period, culminating with ~ 3.4 US billion dollars (CNY 22.5 billion) worth of imports in 2017-18. This represents ~90% of all solar PV imports into India, underscoring the dominant role of large scale Chinese solar manufacturing in the Indian solar story. To strengthen solar PV and electric battery storage manufacturing in India, the Govt. plans to introduce large-scale solar PV deployment tenders, which will mandate setting up a certain scale of solar and battery manufacturing in the country.

Figure 2: Value (in USD Million) of solar PV imports from China and its share in total solar PV imports



Source: Department of Commerce, GoI, Import Export Data Bank.

Going ahead

While rapid large scale deployment of renewables, especially at record low prices point towards a cleaner electricity sector, the transition will not be without its fair share of challenges. Such a paradigm shift will bring into sharper focus some of differing priorities and capacities of the central and state governments. The central government's perspective is informed by macro-economic stability, economic growth, international climate obligations and geo-strategic issues, while states are driven more by local concerns and political realities including energy access and affordability, local jobs and economies etc. A well planned transition will have to take into consideration the state realities, especially the poor financial health and capacity of electricity distribution companies, since a robust grid and economically viable distribution sector is critical to absorb a large share of renewables. Further loss of employment and tax revenue for coal rich states and grid integration issues in states with large concentration of renewable energy (such as Karnataka, Tamil Nadu etc.) will need to be resolved through a more comprehensive and consultative planning process, especially given the rapid pace of the unfolding

transition. Thus, India's renewable energy future is not only dependent on how it deals with the sectoral aspects but also on how it manages some of the governance and political questions.

- *Ashwin Gambhir, Fellow, Prayas (Energy Group)*