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# Risks Growing for India's Coal Sector

## *Over-Capacity, Water Shortages and Renewables Increase Pressure on Coal-Powered Generators*

## Executive Summary

India's coal-fired generation sector is already facing serious problems. Raj Kumar Singh, the country's power minister, warned last year that upward of 20 percent of the country's installed coal capacity was in poor financial condition and had interest payments that exceeded profits. Worse, he said, 25 percent of that group was "totally unviable."[1]

In this report, we argue that this is just the beginning of the ongoing problems facing India's coal-fired generators. We see three major risks confronting the sector; these risks are already manifesting, but we believe they will intensify in the years ahead. These risks are:

1. **The over-building of coal-fired capacity.** The coal construction boom in the first half of this decade has now come to an end but leaves a critical legacy of significant over-capacity. The construction boom in the early 2010s was so pronounced, in fact, that the amount of installed coal-fired capacity in India is now 20 percent higher than the country's peak demand level and fully 50 gigawatts (GW) above average demand levels.

2. **Increasing competition from low-cost renewable and hydro* energy sources, particularly during the monsoon season.** Coal is becoming increasingly uncompetitive in the Indian energy market because of growing competition from cheap renewable solar and wind energy sources. Low-cost renewable energy has a particular advantage during the monsoon season. Complementary to the coal generation dip, wind and hydro generation provide an offsetting peak.

3. **Declining water supplies.** Groundwater levels across India are in decline. Since 2012, both total annual rainfall and monsoon rainfall have been below

* *This report was revised on September 9, 2019 to more clearly define the various categories of energy resources of renewable energy, large hydro and thermal power as included in data from the Government of India's Central Electricity Authority.*

[1] Sushma, U.N. and Anand, N. Cheap renewable energy is killing India's coal-based power plants. *Quartz India*. May 9, 2018.

normal levels across the country (except for 2013 in both cases). This is a major threat for coal generation, which requires substantial amounts of water for steam production and cooling, and has already led to production cuts at several plants on a number of occasions.

Our analysis shows that these problems are already undermining India's coal generator output.

We find that overbuilt coal capacity has left two related problems. First, the utilization rates of individual coal plants have fallen, impairing their economic competitiveness because they must spread their costs over a diminishing number of kilowatt-hours (kWh) sold during the year. Second, over-capacity has burdened the system as a whole since the capital costs of the plants still need covering even if their electric output is not needed.[3]

We also find that the wave of new renewable capacity planned for India, 275GW in total by 2027 and as much as 500GW by 2030, is going to undercut coal across the board. Recent prices for renewable power tenders have come in below the average price of electricity from NTPC, the state-run utility that operates 53GW of coal-fired capacity. Going forward, prices for onshore and offshore wind and solar are expected to continue declining while prices for coal-fired generation are likely to rise. The economics already favor renewables, and we expect the cost disparity between renewables and coal to widen as time goes on.

Finally, we find that water shortage problems forced 61 plant shutdowns from 2013-2017, resulting in roughly 17,000 gigawatt-hours (GWh) of lost generation (and revenue). Water-related problems are certain to worsen as the impacts of climate change continue to manifest, exacerbating the duration and severity both of flooding and drought. The latter is particularly concerning since about 41GW of India's installed thermal capacity is located in drought-affected areas, with about 37GW located in "extreme drought" areas.[4]

It is our conclusion that these issues, coupled with rising concern over climate change and increasingly ambitious government commitments to address it, will be an insurmountable hurdle for India's coal sector.

The report, prepared by the Institute for Energy Economics and Financial Analysis (IEEFA) and the Applied Economics Clinic (AEC), is organized as follows: Chapter 1 provides a brief background of India's electric sector; Chapters 2, 3 and 4 explore the three risks outlined above; Chapter 5 focuses on the financial impacts these risks already are having on both the power and banking sectors and analyses how these risks will continue to affect the two sectors moving forward; and Chapter 6 presents some concluding recommendations.

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[3] Barnes, I. The prospects for HELE power plant uptake in India. IEA Clean Coal Centre. November 2016.

[4] Personal communication with Asar analysts (Vinuta Gopal and Harshit Sharma). Their estimate is based on data from the state natural disaster management monitoring center and WRI's Aqueduct tool to identify thermal capacity in water stressed regions. http://asar.co.in/.

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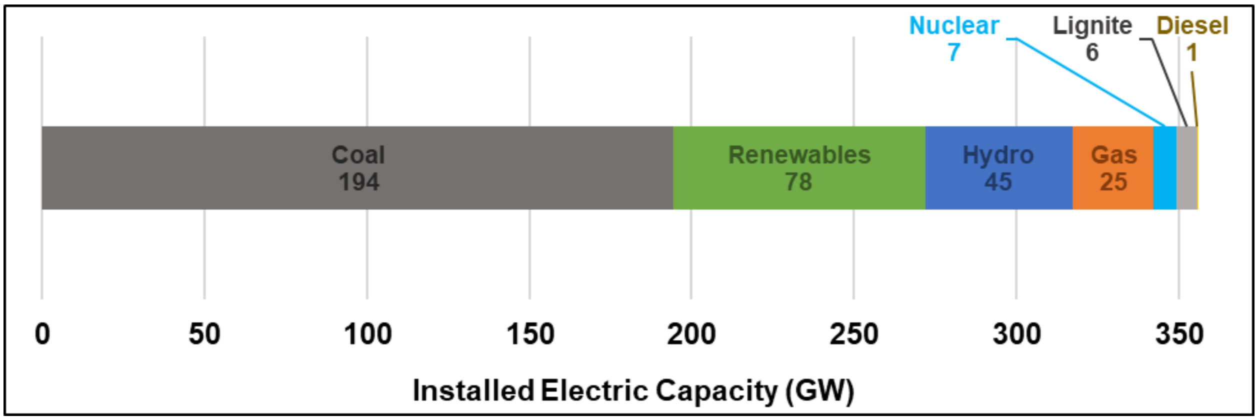
## India's Electric Sector

India's installed electric generating capacity grew from 1.7GW in 1950 to 356GW in March 2019. Of that total, roughly 55 percent is coal-fired (see Figure 1). This dramatic growth had, by the end of 2018, turned India into both the world's third largest coal producer and its third largest importer.[5]

### Figure 1. Indian Total Installed Electric Generating Capacity as of March 31, 2019 (GW)



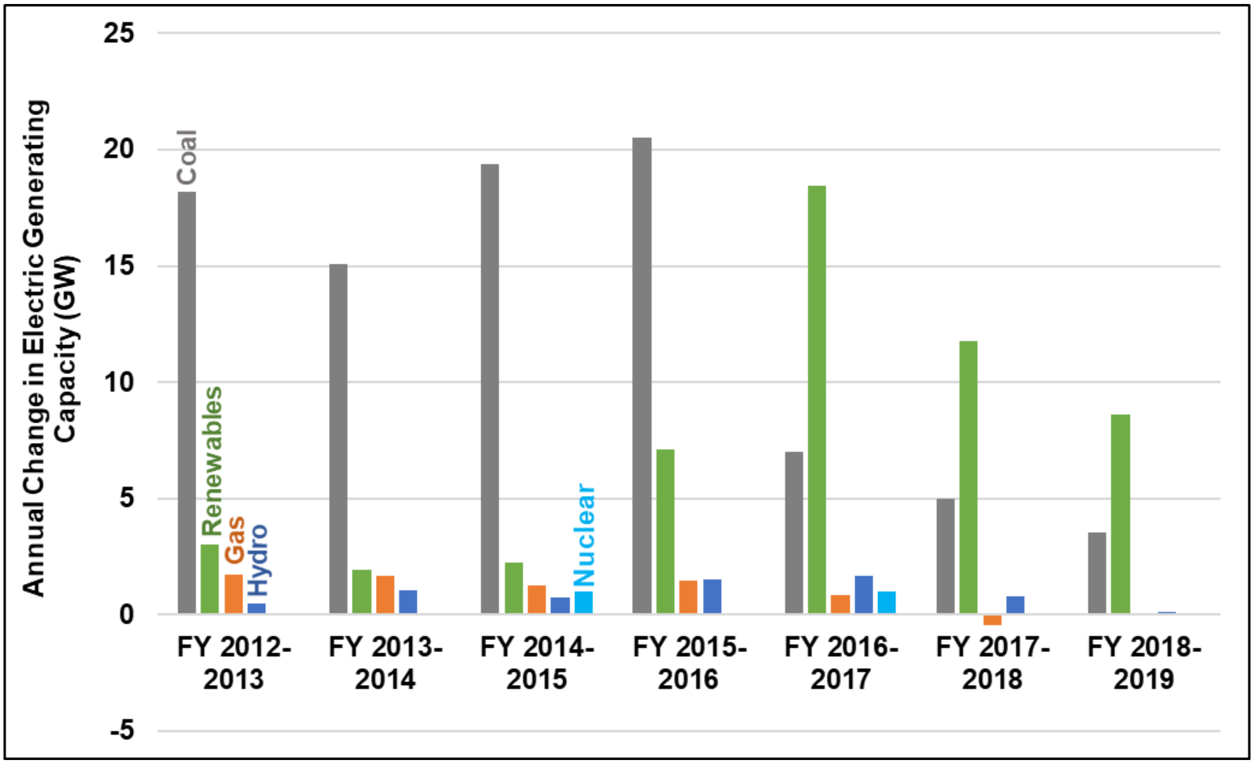

***Note:*** *Lignite was reported as a separate category from coal beginning in November 2018.*

***Source:*** *India Central Electricity Authority (CEA)*[6]

Between fiscal year (FY)[7] 2012-13 and FY 2018-19, India installed 156GW of electric generating capacity, of which 53 percent (88GW) was coal-fired (see Figure 2).[8] Over the same period, 53GW of renewable capacity (including solar, wind, biomass and small hydro) was added, accounting for 34 percent of all capacity additions. The remaining capacity additions were split among natural gas, nuclear and hydro. Since FY2016-17, renewable capacity additions have outpaced coal additions by more than two to one (see Figure 2).

[5] Vishwanathan, S.S., Garg, A. and Tiwari, V. Coal transition in India: Assessing India's energy transition options. *IDDRI and Climate Strategies.* 2018.
[6] Executive Summary on Power Sector. March 2019, Table 4.
[7] The Indian Government reports data according to fiscal years (as opposed to calendar years). The Indian fiscal year runs from April 1 to March 31.
[8] Note that coal capacity also includes lignite, which only started being reported as a separate category from coal in FY 2018-19. For the sake of consistency, we include lignite capacity in the coal category in FY 2018-19 as well.

**Figure 2. Indian Annual Capacity Change by Resource, FY 2012-13 to FY 2018-19**




***Note:*** *Excludes diesel. Lignite is included in coal, which started being reported as a separate category in FY 2018-19.*

***Source:*** *Applied Economics Clinic (AEC) calculations using data from India CEA*[9]

Historically, access to energy in India has been limited, largely as a result of widespread poverty combined with 70 percent of the nation's 1.3 billion people living in rural—often remote—areas.[10] And despite the significant growth in generation capacity, particularly since 2012, an estimated 25 million Indian households[11] still lack access to electricity. Not surprisingly, improving electric access is a top priority for the country.

To tackle this problem, in August 2015, Prime Minister Narendra Modi announced an ambitious plan (called *Saubhagya*) to electrify all Indian households by March 2019. Later, the government announced it was moving up the 100 percent electrification target date to December 31, 2018. In April 2018, the government declared that all Indian villages had access to electricity, ahead of schedule—a significant national achievement. (However, the government set a relatively low threshold for village electrification defining any village where a minimum of 10

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[9] Executive Summary on Power Sector, FY 2011-12 through FY 2018-19.

[10] Singh, R.K. Power for All in India! How Close Is Modi's Goal? Bloomberg. April 26, 2018.

[11] Tripathi, B. 15 Million Indian Households Have Meters But No Electricity. BloombergQuint. November 1, 2018.

percent of the village's homes have electricity access as being "connected."[12]) Despite the unequivocal progress facilitated by the electrification plan, since the government's triumphant announcement of 100 percent electricity access, there have been multiple reports and survey results indicating that significant access and reliability issues remain.[13]

Looking at per capita usage, there has been significant growth in average residential electric consumption in India since 1980: climbing from 142kWh to 1,149 kWh in fiscal year FY[14] 2017-18.[15] Still, India's per capita electric use is low when compared to that of other more-developed countries (see Table 1).

## Table 1. Per Capita Electric Consumption Around the World

| Country | kWh per capita |
|---|---|
| Bangladesh | 350 |
| Chile | 4,180 |
| China | 4,280 |
| Iceland | 53,910 |
| **India** | **1,149** |
| Italy | 5,080 |
| Korea | 10,620 |
| Pakistan | 500 |
| South Africa | 4,030 |
| USA | 12,830 |

*Sources: Government of India and the International Energy Agency*[16]

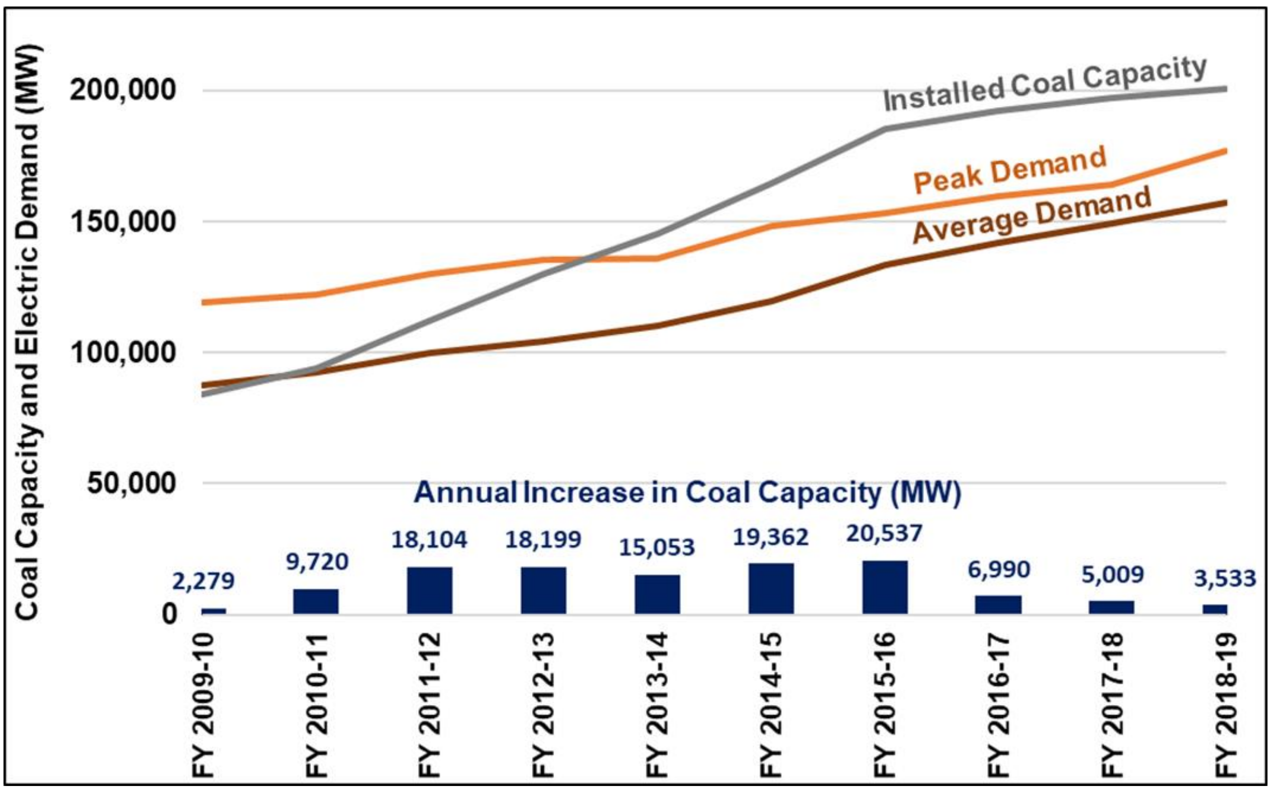
[12] BBC News. India says all villages have electricity. April 30, 2018.
[13] An internal report by the Union Rural Development Ministry (as reported in The New Indian Express) found that approximately 5,000 Indian villages still lacked electricity as of July 2018. (Source: Banakar, P. Rural electrification: 'Power' to the people? Not in these hamlets. The New Indian Express. July 8, 2018.) A 2018 survey of 360,000 villages by the Central Rural Development Ministry found that almost 25,000 villages did not have electricity available for domestic use. (Source: Ministry of Rural Development. Government of India. Villages with Availability of Electricity for Domestic Use.)
In rural states such as Bihar, Madhya Pradesh, Odisha, and West Bengal, less than 40 percent of households had access to electricity from the grid in 2018 (Source: Jain, A., Tripathi, S., Mani, S., Patnaik, S., Shahidi, T., & Ganesan, K. Access to Clean Cooking Energy and Electricity – Survey of States (ACCESS) 2018. *Council on Energy, Environment and Water (CEEW)*. November 2018.)
[14] The Indian Government reports data according to fiscal years (as opposed to calendar years). The Indian fiscal year runs from April 1 to March 31.
[15] Government of India, Ministry of Power, Central Electricity Authority. Executive Summary on Power Sector. February 2019, p. 31.
[16] The India data is for FY2017-18, it is from the CEA resource cited above. Statistics for the remaining countries are for 2016 from IEA's World Energy Balances 2018.

## Risks from Coal-Fired Over-Capacity

India admittedly faces a delicate balance in the development of its energy sector: how to improve access to electricity and support the energy needs of a quickly growing economy while avoiding building too much capacity. But it is clear that India has substantially overbuilt the country's coal-fired generation sector.

The early 2010s construction boom was so pronounced, in fact, that the amount of installed coal-fired capacity in India is now 20 percent higher than the country's peak demand level and fully 50GW above average demand levels (see Figure 3). Even if India's FY 2018-19 peak demand were increased by 10 percent (a hypothetical figure meant to account for the country's ongoing rural electrification efforts), coal generating capacity by itself would still be greater than peak demand.

**Figure 3. Indian Installed Coal Capacity, Coal Capacity Additions, Peak Electric Demand and Average Electric Demand**

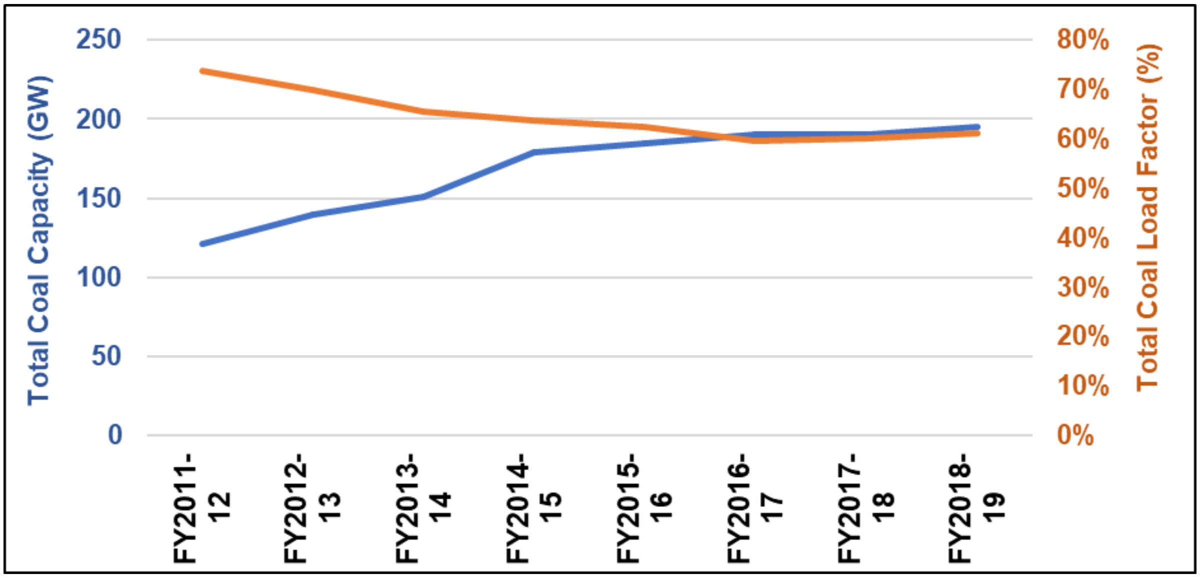



*Source: India CEA and IEEFA calculations.*[17]

[17] Capacity data: India CEA. Monthly Reports Archive–Executive Summary. 2009-2019. Peak load data: India CEA. Power Supply Reports–Power Supply Position - Peak. 2009-2019. Average demand is calculated by dividing India's total generation for the Fiscal Year by the number of hours in a year (8,760).

Importantly, India has 123GW of installed renewable and hydro capacity, both of which have lower marginal costs than coal-fired generation. This is a big problem for Indian coal generators, as can be seen in Figure 4: as India's coal capacity has climbed, average plant utilization rates have fallen.

**Figure 4. Indian Total Coal-Fired Capacity (GW) and Plant Load Factor (percent)**




*Source: India CEA.*[18]

Additionally, Figure 4 understates the true scope of the problem since the coal plant load factors published by India's Central Electricity Authority adjust for an estimated number of planned shutdowns *and* unplanned shutdowns—such as those due to lack of water or fuel. This means that CEA plant load factors overstate how much a plant is utilized. True plant utilization rates (called capacity factors) for coal-fired generators are approximately 3-4 percent lower than the CEA's plant load factor data over the last three years (see Table 2).

[18] India CEA. Monthly Reports Archive – Generation Reports. Fuel Wise Details – Coal/Lignite/Multi-fuel. 2012-2019.

## Table 2. Utilization Rates by Energy Type, FY 2015-16 to FY 2017-18

| | FY 2015-16 | FY 2016-17 | FY 2017-18 |
|---|---|---|---|
| **Capacity Factor** | 58% | 57% | 57% |
| **Plant Load Factor** | 62% | 60% | 60% |
| **Difference** | 4% | 3% | 3% |

*Source: India CEA and IEEFA.*[19]

Not surprisingly, this decline in utilization has led to significant financial troubles for coal utilities and India's power distribution companies[20]

In May 2018, India's power secretary said that 20 percent of India's total coal capacity had been identified as "stressed assets" (assets with interest payments exceeding profits) and that one-fourth of those assets had become "completely unviable."[21] Credit Suisse estimated the value of these stressed assets at 2.5 trillion Rupees (Rs), or US$35 billion.[22]

As difficult as the current financial situation is for India's coal-fired generation, it could have been much worse: A 2018 IEEFA analysis found that, between 2010 and June 2018, 573GW of planned coal capacity was cancelled or shelved.[23] So far this year, state-run utility NTPC has cancelled another 9.3GW of proposed coal-fired power projects.[24]

It is also important to note that this surge in coal-fired capacity has not resolved the country's electric access issues; in November 2018, it was estimated that 15 million Indian households still lack access to electricity.[25]

[India has made significant strides in increasing electric access, but adding large-scale, centralized capacity does not necessarily improve access to electricity. In addition, electric access is uneven across the country: India's eastern region

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[19] Plant load factor data from India CEA. Monthly Reports Archive – Generation Reports. Fuel Wise Details – Coal/Lignite/Multi-fuel. 2012-2018. Utilization rate calculations provided by Kashish Shah, Institute for Energy Economics and Financial Analysis (IEEFA). See also: Buckley, T. and Shah, K. "IEEFA India: New record with renewable energy installations 40 times higher than thermal." Institute for Energy Economics and Financial Analysis (IEEFA). January 29, 2019.
[20] In India, power distribution companies (DISCOMs) are companies that do not generate electricity themselves but purchase it from a generator and supply it to the final customer. Usually, DISCOMs are run by central and state governments, but they can also be privately owned.
[21] Sushma, U.N. and Anand, N. Cheap renewable energy is killing India's coal-based power plants. *Quartz India*. May 9, 2018.
[22] Financial Times. India's renewable rush puts coal on the back burner. December 31, 2018.
[23] Buckley, T., & Shah, K. IEEFA update: India coal plant cancellations are coming faster than expected. Institute for Energy Economics and Financial Analysis (IEEFA). 2018.
[24] Shah, K. Continued decline in Indian thermal capacity additions. *Energyworld*. April 10, 2019.
[25] Tripathi, B. 15 Million Indian Households Have Meters But No Electricity. BloombergQuint. November 1, 2018.

(comprising the states of Bihar, Jharkhand, West Bengal, Sikkim and Odisha) has among the highest poverty rates in the country[26] (excluding West Bengal and Sikkim) and the lowest rates of electric access (60 percent or less of households).[27]]

## Risk of Competition from Renewable Energy Sources

Coal is facing increasing competition from renewable energy sources, which continue to decline in cost and offer India a path to expanding electricity access while also reducing the country's serious air pollution problems and helping it to comply with its emission reductions commitments under the Paris Agreement.

Capacity additions of renewable energy generation have greatly outpaced coal capacity additions in the last three fiscal years (2016-17 to 2018-19) and all indications are that this will continue going forward. India's 2018 *National Electricity Plan* calls for 275GW of total renewable capacity by 2027. And India's secretary of the Ministry of New and Renewable Energy recently suggested that 500GW of renewables will be needed if the country is to reach its goal of generating 40 percent of its electricity from non-fossil fuel resources by 2030.[28]

### *The Monsoon Example*

During the monsoon in India, coal generation dips and wind and hydro generation increase—a proxy that underscores the risks facing coal capacity in the country as more and more renewable capacity is brought online. Once built, renewable capacity has zero variable costs of generation giving it a competitive edge over thermal power plants that must purchase their fuel, especially plants relying on expensive imported coal.

Every year, usually between June and September, India experiences the monsoon season. During this period, prevailing winds in the Indian Ocean change direction, causing warm, moist air to move toward the subcontinent—bringing heavy rains with it.

[26] Reserve Bank of India. Handbook of Statistics on Indian Economy. Table 162: Number and Percentage of Population Below Poverty Line. September 16, 2013.
[27] Singh, R.K. and Sundria, S. Living in the Dark: 240 Million Indians Have No Electricity. *Bloomberg*. January 24, 2017.
[28] Gupta, U. India will tender 500 GW renewable capacity by 2028. *pv magazine*. January 8, 2019.

## Monsoon Impacts Indian Economy

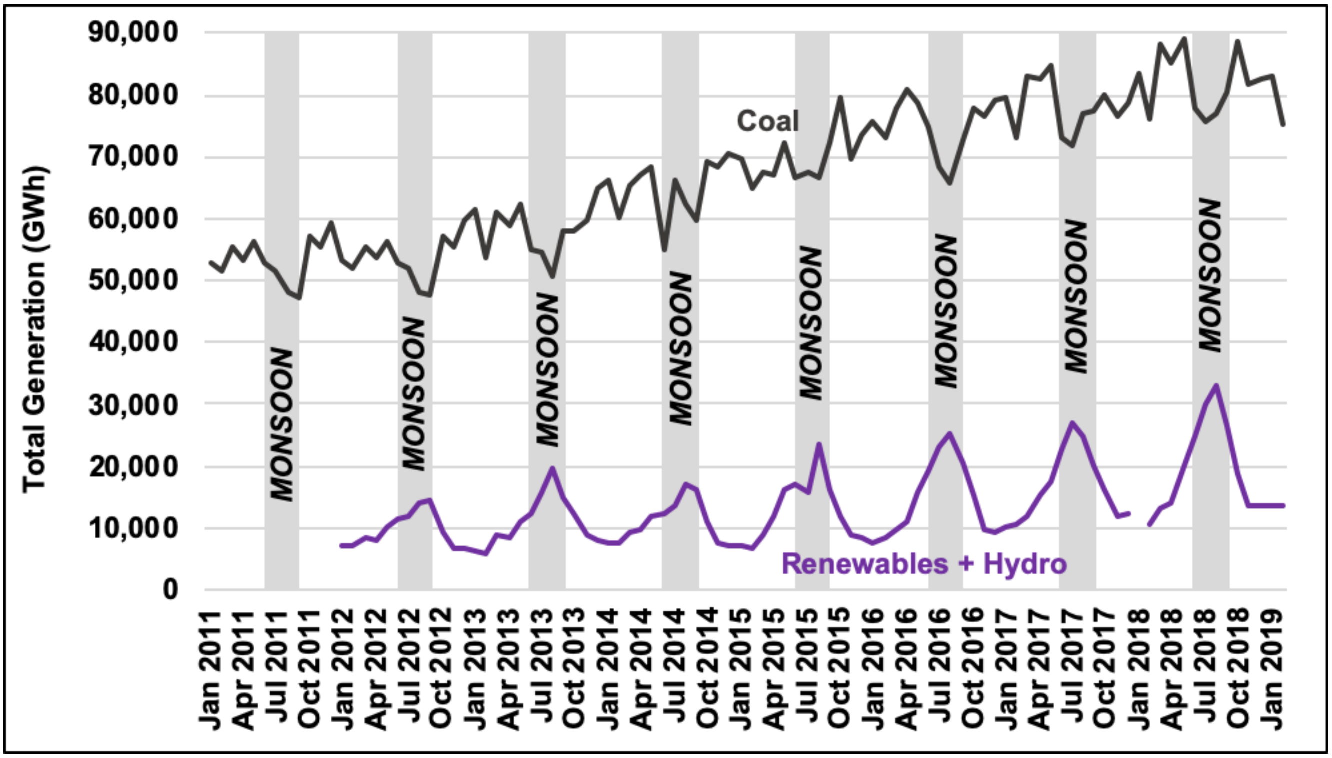
The monsoon plays a critical role in India's economy; agriculture, for example, relies on the monsoon rains to irrigate cropland, fill rice paddies and provide fodder and drinking water for livestock. When monsoon rainfall is less than normal, the economy suffers as farmers have weak harvests and lower-than-expected hydroelectric generation drives up electricity prices.[A] When monsoon rains are greater than normal, flooding can batter the economy, cutting agricultural production and impairing deliveries of key supplies, including coal, as well as negatively affecting human well-being. For example, the 2017 Monsoon flooding killed more than 1,000 people in India, Bangladesh and Nepal and affected 40 million people overall.[B]

[A] National Geographic. Resource Library: Monsoon. 2019.
[B] Siddique, H. South Asia floods kill 1,200 and shut 1.8 million children out of school. *The Guardian*.

For coal generation, the impact of the monsoon is well-documented—output drops (see Figure 5).[29] Specifically, between 2011 and 2018, coal generation was 8 percent lower during the monsoon season than its annual average.[30] Some of the decline is due to regular maintenance activities undertaken during these months, but the decline is also due to rising generation from no and low-cost hydro and renewable wind resources during the monsoon months. (Unlike hydro and wind, solar generation declines during the monsoon, as shown in Figure 6.)[31]

[29] Part of the reason for this trend is that coal plants have their scheduled maintenance during the Monsoon season.
[30] Calculated by taking the average monsoon generation (June-September) as a percent of the average generation for the rest of the year (January-May, October-December).
[31] CEA sometimes publishes generation data in GWh and sometimes in million units (MU). The two measures are equivalent, since one unit is defined as one kWh. This report utilizes GWh throughout for consistency.

**Figure 5. Indian Coal versus Hydro and Renewable Wind and Solar Generation (GWh)**




***Note**: The renewables + hydro line includes hydro, wind and solar generation. Hydro generation data begins in January 2012 (see below). Wind and solar generation data begins in April 2015 and is missing for January 2018.*

*Source: India CEA.*[32]

The loss of these electricity sales during the monsoon season makes coal plants less competitive because their costs must be recovered through fewer kilowatt-hours of output, thereby raising their per kWh cost of electricity. Just since January 2017, India's total installed wind capacity has climbed 19 percent, from 29GW to 36GW.[33] Similarly, maximum monthly wind output during the monsoon season nearly doubled between 2015 and 2018 rising from 6,600 gigawatt hours (GWh) in 2015 to 11,800 GWh in 2018.

[32] 1) India CEA. Monthly Reports Archive – Renewable Energy Generation Reports. 2015-2019; 2) India CEA. Monthly Reports Archive – Generation Reports. Fuel Wise Details – Coal/Lignite/Multi-fuel. 2012-2019; 3) India CEA. Monthly Reports Archive – Generation Reports. Summary – Regionwide. 2012-2019.

[33] Sources: (1) India CEA. Monthly Reports Archive – All India Installed Capacity. January 2017; (2) India CEA. Monthly Reports Archive – All India Installed Capacity. March 2019. Note that wind and solar capacity data was unavailable from CEA before January 2017.

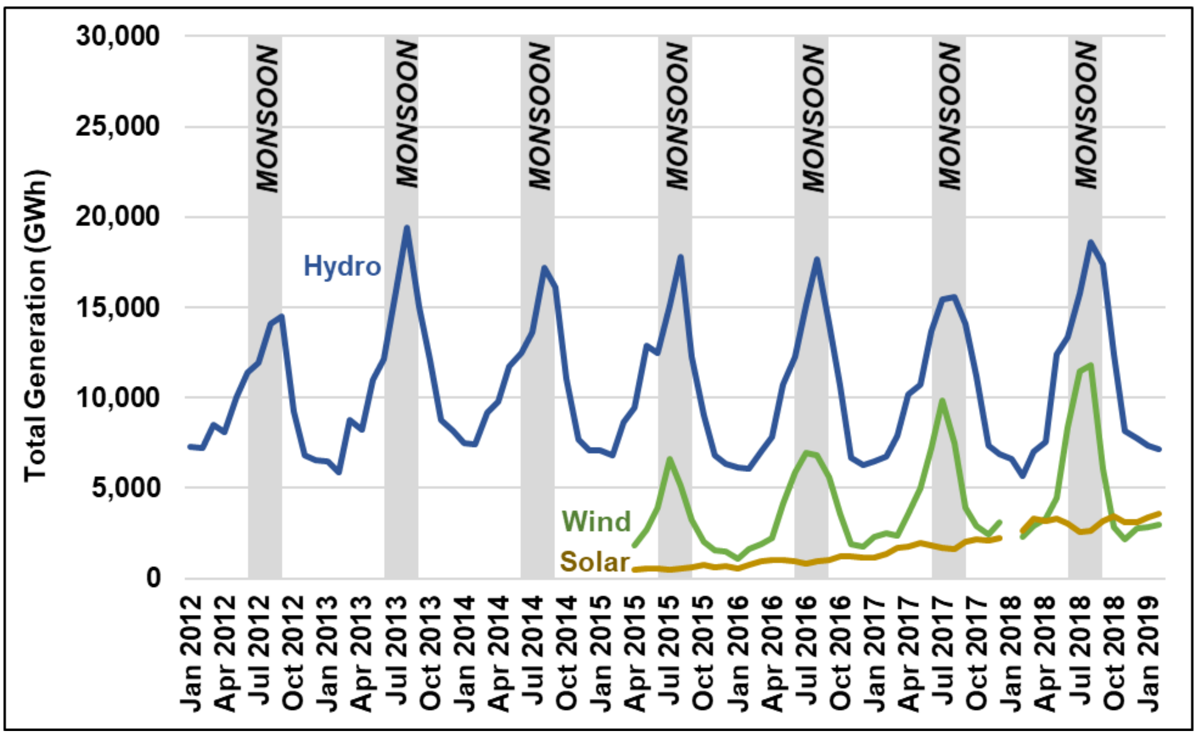
## *Growing Risk from Solar*

In addition to the increasing competition from wind and hydro resources, India's coal-fired power plants also face growing competition from solar throughout the year (Figure 6).

Since January 2017, India's total installed utility scale solar capacity more than tripled, from 9GW to 28GW (with another 3.9GW of mostly behind the meter rooftop solar capacity).[34] This has resulted in annual solar generation jumping from 740GWh in 2015 to 3,600GWh in 2019.

Rising generation coupled with low prices has turned solar into an important source of competition for coal generation. Utility-scale solar in India has sold recently for as little as 2.4 Rs/kWh (about US$0.035/kWh[35]) which is roughly a 70 percent decline in price in just a few years.[36]

**Figure 6. Indian Hydro, Wind and Solar Generation (GWh)**

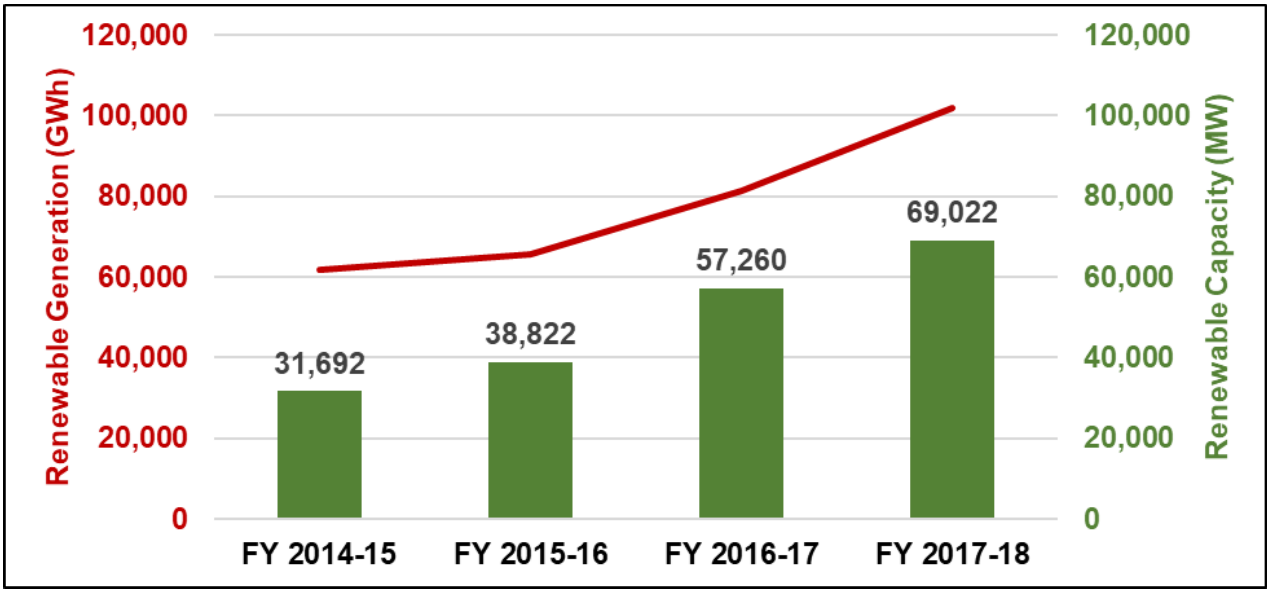



***Note**: Solar and wind generation data is missing for January 2018.*
*Source: India CEA.*[37]

[34] Sources: (1) India CEA. Monthly Reports Archive – All India Installed Capacity. January 2017; (2) India CEA. Monthly Reports Archive – All India Installed Capacity. March 2019. Note that wind and solar capacity data is unavailable from CEA before January 2017.
[35] Using the exchange rate on Oanda as calculated April 16, 2019.
[36] Tongia, R. and Gross, S. Working to turn ambition into reality: the politics and economics of India's turn to renewable power. *Brookings*. September 2018, p.iii.
[37] (1) India CEA. Monthly Reports Archive – Renewable Energy Generation Reports. 2015-2019; 2) India CEA. Monthly Reports Archive – Generation Reports. Summary – Regionwide. 2012-2019.

India's total renewable energy capacity grew by 54 percent (from 32GW to 69GW) over the past four years (Figure 7). Renewable capacity additions outpaced coal net additions in the past four years, a reverse of the trend from previous years (Figure 8).

**Figure 7. Indian Renewable Capacity and Generation by Fiscal Year**

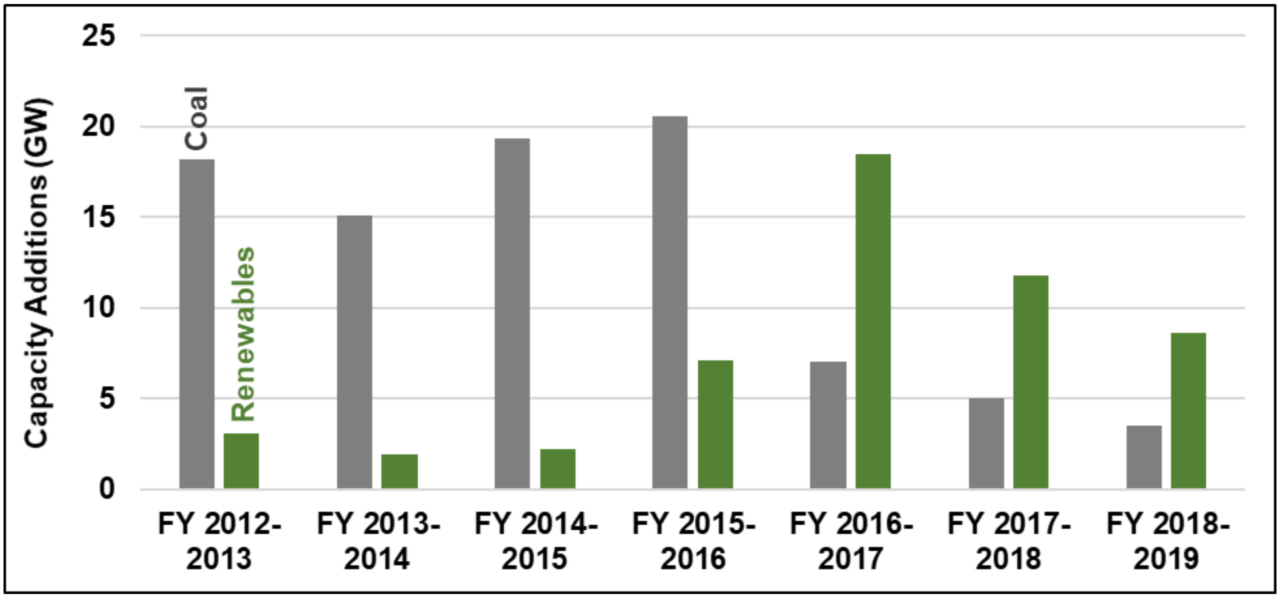



***Note**: Renewables here include: solar, wind, biomass and small hydro (not large hydro, which is included in Figure 6).*

*Source: India CEA.*[38]

[38] India CEA. Monthly Reports Archive–Executive Summary. 2015-2018.

## Figure 8. Indian Coal and Renewable Net Capacity Additions, FY 2010-11 to FY 2018-19




*Source: India CEA.*[39]

Since FY 2010-11, solar prices have dropped by more than 75 percent in India (Table 3).[40] In December 2010, solar auction prices were at an all-time high of 12.16 Rs/kWh, a figure which fell to 2.45 Rs/kWh by May 2017. The IEA reported that more than half of all of India's power sector spending in 2016 went to renewables and that coal investments had decreased from their peak of approximately 40GW in 2009 to 5GW in 2016.[41]

## Table 3. Annual Average Solar Auction Prices, 2010-2017 (Rs/kWh)

| Average Solar Auction Price | |
|---|---|
| FY 2010-11 | 12.16 |
| FY 2011-12 | 8.58 |
| FY 2012-13 | 7.61 |
| FY 2013-14 | 7.51 |
| FY 2014-15 | 6.75 |
| FY 2015-16 | 5.41 |
| FY 2016-17 | 4.25 |
| FY 2017-18 | 2.74 |

*Source: Monthly solar weighted average price data was averaged over each full fiscal year.*[42]

[39] India CEA. Monthly Reports Archive – Executive Summary. 2012, 2019.
[40] Economic Times. Solar tariffs in India have fallen by 73 percent since 2010. March 24, 2017.
[41] Evans, S. Seven charts show why the IEA thinks coal investment has already peaked. *CarbonBrief.* July 11, 2017.
[42] Data from: Shyam, R. et al. Success Story of Solar Parks in India Vis-à-vis Beginning of a New Era of Solar Tariff. Akshay Urja: Renewable Energy, Vol 11(1,2). October 2017.

# Risk of Inadequate Water Supply

Coal-fired power plants require significant amounts of water for steam to produce energy, cool equipment, perform system maintenance and clean sites and equipment.[43] That water is becoming increasingly hard to come by in India.

For starters, the amount of rain delivered during the monsoon season has been declining, dropping by roughly 20 percent in recent years.[44] In addition, it has become less predictable while the number of heavy, and often harmful rainfall events, has increased.[45,46]

In addition, recent studies have shown that the country's groundwater resources are being highly stressed. In 2015, the Royal Meteorological Society found that about 15 percent of India's groundwater resources are overexploited.[47] This situation will become progressively worse as the population and economy continue to grow rapidly. Growing over-reliance on groundwater for agricultural irrigation and an expanding industrial sector, including coal generation,[48] are of particular concern.

In India, groundwater levels are determined by testing strategically placed wells, throughout the country, four times per year: March/April/May (pre-monsoon), August (monsoon), November (post-monsoon) and January (winter). Figure 9 presents the share of sampled wells for which water levels fell from the same month a year prior, averaged over the period FY 2011-12 to FY 2016-17. For example, on average, 56 percent of wells observed in January exhibited lower water levels than they did the year prior over the six-year period.

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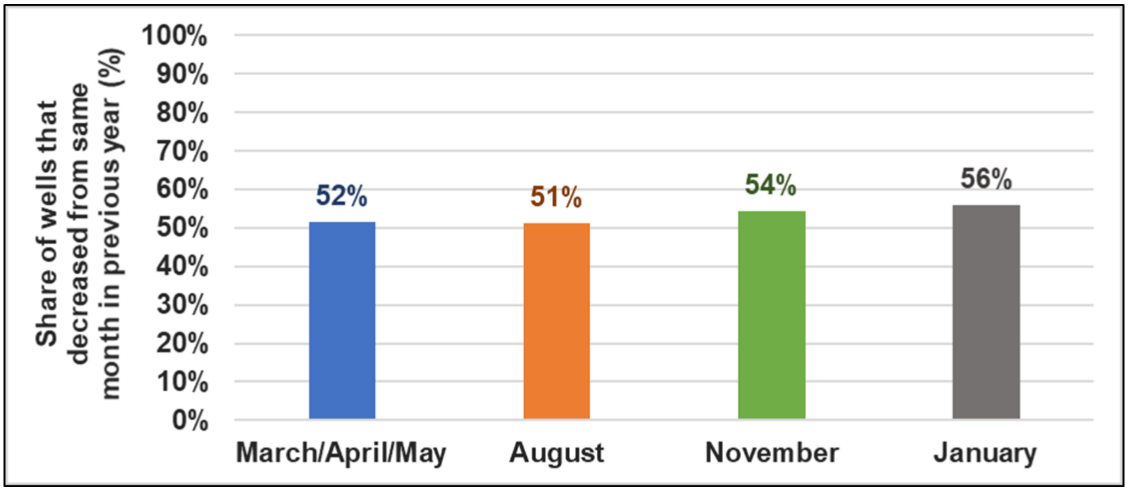
[43] Union of Concerned Scientists. How it Works: Water for Coal. 2014.
[44] Roxy, M.K. et al. Drying of Indian subcontinent by rapid Indian Ocean warming and a weakening of land-sea thermal gradient. *Nature*, 6, 7423. 2015.
[45] Athreye, Viki. Climate Change and Its Impact on Monsoon in India. 2018.
[46] The World Bank. India: Climate Change Impacts. 2018.
[47] Ibid.
[48] Chopra, R. Environmental Degradation in India: Causes and Consequences. International Journal of Applied Environmental Sciences, 11(6), 1593-1601. 2016.

**Figure 9. Share of Wells Between FY2011-12 and FY 2016-17 That, on Average, Had Less Water Than in the Same Month in the Previous Year**



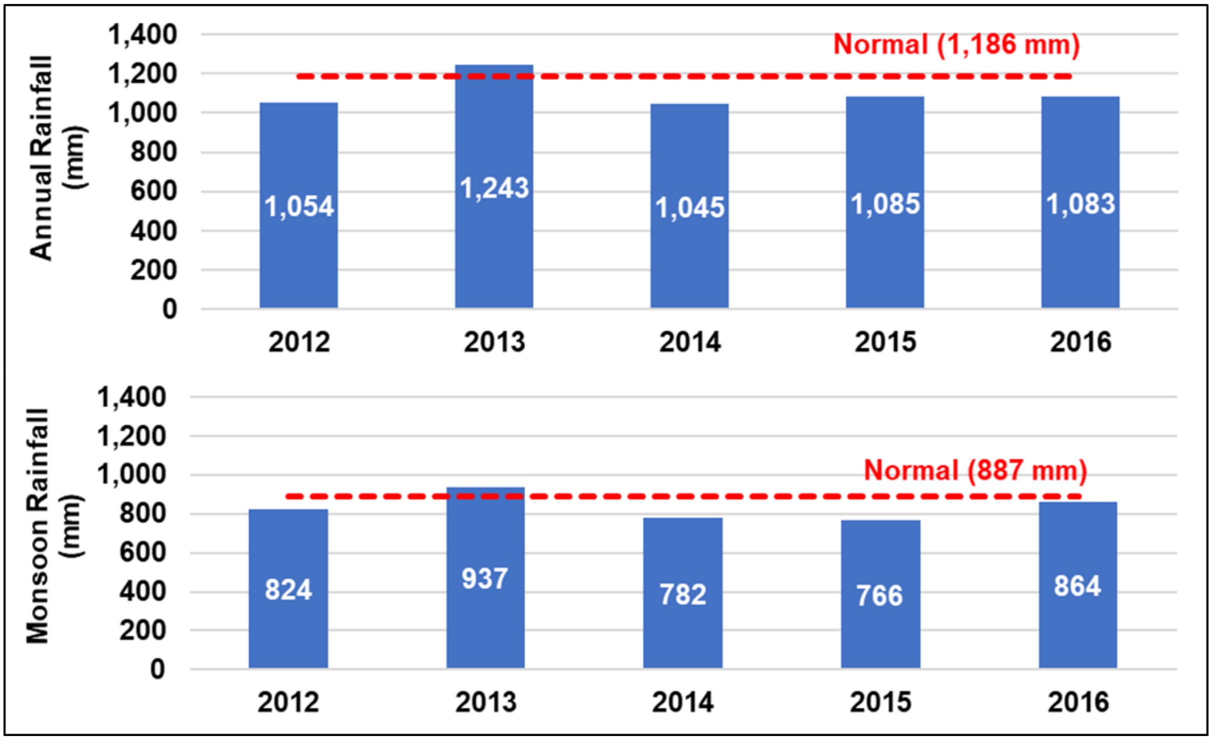

*Source: India Central Ground Water Board (CGWB).*[49]

A 2016 report by Greenpeace[50] found Indian baseline water stress (i.e. total annual water withdrawals expressed as a percentage of total annual available flow) to be among the highest in the world. Greenpeace also reported that 19 percent (36GW) of the existing Indian coal fleet (191GW) is in regions where annual water withdrawal is greater than annual available flow (called *red-listed areas*).

These problems are expected to become more severe as average global temperatures continue to rise. In particular, this is likely to exacerbate the decline in monsoon rainfall and to increase its unpredictability,[51] resulting in more frequent and more widespread drought conditions, especially in Jharkhand, Orissa and Chhattisgarh in northwestern India—poorer regions that are least capable of handling drought conditions.[52] Since 2012, both total annual rainfall and monsoon rainfall have been below normal levels[53] across India (except for 2013 in both cases, see Figure 10).

[49] India Central Ground Water Board (CGWB). Ground Water Scenario in India. Ministry of Water Resources, Government of India. 2012-2017.
[50] Cheng, I and Lammi, H. The Great Water Grab: How the Coal Industry is Deepening the Global Water Crisis. Greenpeace International. March 2016.
[51] Ibid.
[52] Ibid.
[53] Normal rainfall levels are defined by the Indian Meteorological Department as 89 cm for the monsoon and 118.6 cm annually.

**Figure 10. Total Annual Rainfall and Total Monsoon Rainfall, 2012-2016**




*Source: India Meteorological Department.*[54]

Ultimately, less water—either from lower than normal rainfall or from decreasing groundwater levels—poses major risks to coal generation in India and may result in forced outages when water resources are insufficient for plant operation.[55,56] According to India's ministry of power, insufficient water supplies for cooling or other operations resulted in 61 coal plant shutdowns between 2013 and February 2017—resulting in approximately 17,000GWh of lost generation (see Table 4).[57]

[54] Kaur, S. & Purohit, M.K. Rainfall Statistics of India. India Meteorological Department. 2012-2016.
[55] Roxy, M.K. et al. Drying of Indian subcontinent by rapid Indian Ocean warming and a weakening of land-sea thermal gradient. *Nature*, 6, 7423. 2015.
[56] Athreye, Viki. Climate Change and Its Impact on Monsoon In India. 2018.
[57] Dharmadhikary, S., Sandbhor, J. (Manthan Adhyayan Kendra) Loss of 7 Billion Units Power Generation Due to Raw Water Shortage at Coal Based Thermal Power Stations in India from June 2016 to April 2017. May 18, 2017.

## Table 4. Indian Generation Lost Due to Lack of Water, April 2013 to February 2017

| Year | Number of Units | Lost Generation (GWh) |
|---|---|---|
| 2013-14 | 16 | 5,253 |
| 2014-15 | 9 | 1,258 |
| 2015-16 | 15 | 4,989 |
| 2016-Feb 2017 | 21 | 5,870 |
| **Total** | **61** | **17,370** |

*Source: Adapted from Dharmadhikary, Sandbhor (Manthan Adhyayan Kendra).*[58]

According to 2018 research from the World Resources Institute (WRI), freshwater-cooled thermal power plants located in high water-stress areas have a 21 percent lower average capacity factor, compared to plants located in low and medium water-stress areas (see Figure 11).[59] In another 2018 paper,[60] WRI found that 14 of India's top 20 largest thermal power utility companies experienced water shortage-related disruptions at least once between 2013 and 2016, losing more than US$1.4 billion in potential revenue. Such trends are likely to continue as climate change exacerbates the severity of both droughts and floods.

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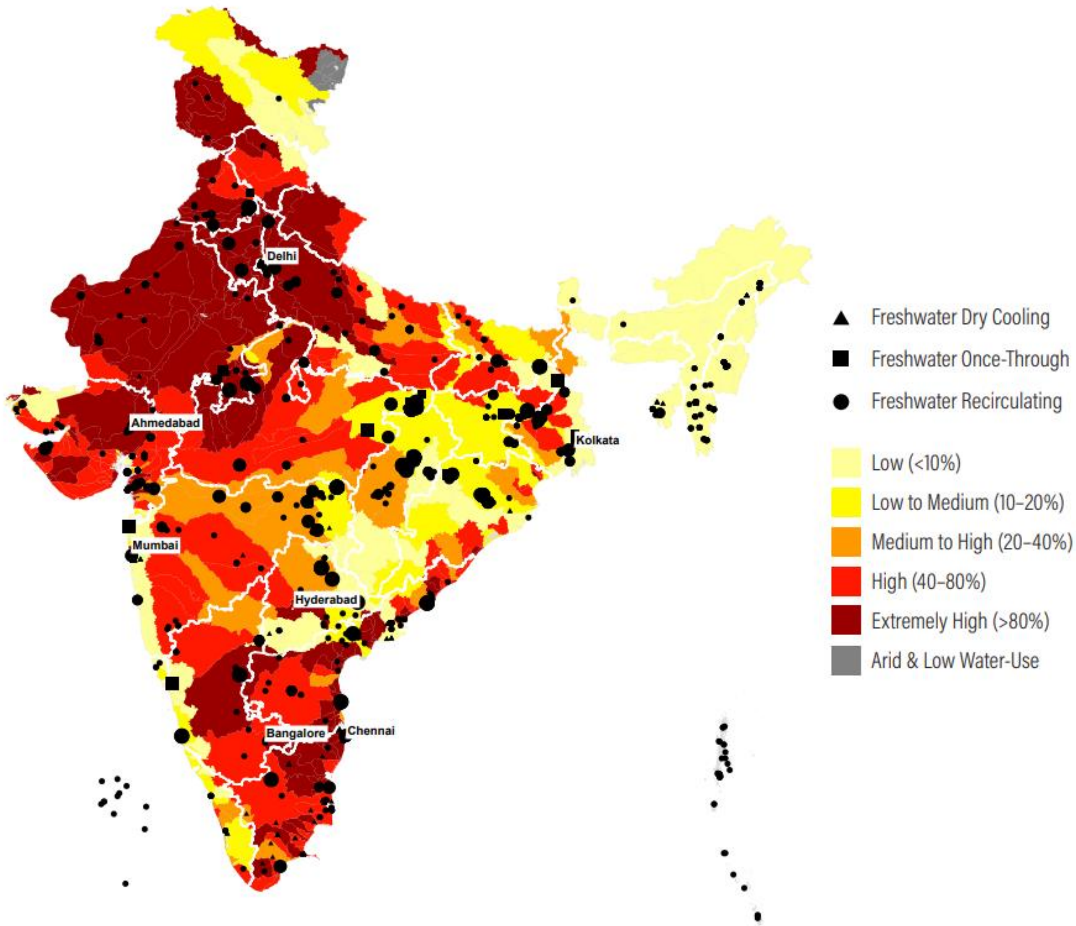
[58] Adapted from Dharmadhikary, S., Sandbhor, J. (Manthan Adhyayan Kendra) Loss of 7 Billion Units Power Generation Due to Raw Water Shortage at Coal Based Thermal Power Stations in India from June 2016 to April 2017. May 18, 2017.
[59] Luo, T., Krishnan, D., & Sen, S. Parched Power: Water Demands, Risks, and Opportunities for India's Power Sector. Working Paper. Washington, DC: *World Resources Institute*. 2018, p. 21.
[60] Luo, T., Krishnan, D., & Sen, S. Parched Power: Water Demands, Risks, and Opportunities for India's Power Sector. Working Paper. Washington, DC: *World Resources Institute*. 2018.

## Figure 11. India's Freshwater-Cooled Thermal Power Plants by Water-Stressed Areas




*Source: Reproduced from Luo, Krishnan, & Sen.*[61]

Further compounding the issue of limited water availability is that many thermal power plants in India are failing to comply with legal water withdrawal limits. A July 2019 note by the Manthan Adhyayan Kendra water and energy research centre found that just 51 percent of thermal power plants were in compliance with existing water use regulations.[62] This would be problematic in any context but is particularly concerning given the increased occurrence of severe drought in India. In February, for example, almost half of India's land area was experiencing drought conditions—with at least 15 percent falling in the "extreme drought" category.[63] Almost 41GW of

[61] Luo, T., Krishnan, D., & Sen, S. Parched Power: Water Demands, Risks, and Opportunities for India's Power Sector. Working Paper. Washington, DC: *World Resources Institute*. 2018, Figure ES-4, p. 5.
[62] Manthan Adhyayan Kendra. Wide-spread Non-Compliance as Thermal Power Plants don't Meet Water Use Norms. July 2019.
[63] The Hindu. Nearly 50% of India currently facing drought: IIT Gandhinagar scientists. February 28, 2019.

India's thermal capacity is located in the drought-affected areas, with about 37GW located in "extreme drought" areas.[64]

## The Risks Become Reality—Lost Generation, Rising Financial Instability

The manifestation of risks to Indian coal generation—including overbuilt coal capacity, competition from renewables and water availability issues—can be seen already in lost generation and growing sector-wide financial risk. Going forward, these risks are expected only to increase.

In particular, India's coal generating resources will face much stiffer competition from renewable energy in the next ten years with the country pushing to meet its goal of adding 275GW of new green generation (primarily wind and solar) to the grid by 2027. The amount of planned new renewable capacity outlined in the2018 *National Electricity Plan* is almost four times greater than the amount of new non-renewable capacity expected in the same period (see Table 5).

**Table 5. Planned Indian Capacity Additions and Retirements**

| Planned Capacity Position (GW) | | | |
|---|---|---|---|
| **Source** | **2017-22** | **2022-27** | **TOTAL** |
| Solar | 100 | 50 | 150 |
| Wind | 60 | 40 | 100 |
| Small Hydro and Biomass | 15 | 10 | 25 |
| **Total Renewables** | **175** | **100** | **275** |
| Coal | 6 | 46 | 53 |
| Gas | 0 | 0 | 0 |
| Large Hydro | 7 | 12 | 19 |
| Nuclear | 3 | 7 | 10 |
| **Total Non-Renewables** | **17** | **65** | **82** |
| Retirements | 23 | 26 | 48 |
| **Total Capacity Addition (less retirements)** | **169** | **140** | **309** |

*Source: India CEA.*[65]

While it will undoubtedly be a stretch, there are promising signs that the Indian government will deliver on its renewable energy promises. In FY 2018-19, India installed two-and-a-half times more renewable capacity than thermal capacity—

[64] Personal communication with Asar analysts (Vinuta Gopal and Harshit Sharma). Their estimate is based on data from the state natural disaster management monitoring center and WRI's Aqueduct tool to identify thermal capacity in water-stressed regions. http://asar.co.in/.
[65] National Electricity Plan: Volume 1. Government of India, Ministry of Power, CEA. January 2018, Tables 5.9 through 5.16.

3.4GW of thermal versus 8.6GW of renewable.[66] In the first nine months of 2018, the Indian CEA reported that thermal capacity additions were at their lowest levels in the last decade, while the rate of renewable capacity additions was double the level of the last three years.[67] In addition, Power Minister Raj Kumar Singh has announced that he expects India will "over-achieve" its 2022 renewable energy capacity target of 175GW (see Table 5 above).

This ongoing renewable buildout is already having an impact on India's coal investments; an impact that is certain to increase in the future, particularly since the new renewables coming online are priced well below the average price of coal-fired electricity.

All but four solar and wind auction prices in India since June 2018 have come in below 3.00 Rs/kWh. The lowest solar tariff since June 2018 was 1.24 Rs/kWh (equal to approximately US$0.018/kWh)[68] and the lowest wind tariff was 2.51 Rs/kWh (equal to approximately US$0.036/kWh) (see Table 6)—both are among all-time lows for Indian power prices.[69]

### Table 6. Wind and Solar Auction Prices Since June 2018 (Rs/kWh)

| | Wind | | Solar | |
|---|---|---|---|---|
| | Lowest | Highest | Lowest | Highest |
| Jun-18 | 2.51 | 2.52 | -- | -- |
| Jul-18 | 2.85 | 2.87 | 2.44 | 2.71 |
| Aug-18 | 2.77 | 2.83 | 2.59 | 2.79 |
| Sep-18 | 2.52 | 2.52 | 2.44 | 2.45 |
| Oct-18 | -- | -- | 2.92 | 2.92 |
| Nov-18 | -- | -- | 3.29 | 3.29 |
| Dec-18 | -- | -- | 3.02 | 3.08 |
| Feb-19 | 2.82 | 2.83 | 1.24 | 2.75 |
| Mar-19 | -- | -- | 2.48 | 2.49 |

*Source: Data compiled by IEEFA from sources including Mercom India and ET Energy World.*

In February 2017, solar energy for the 750MW plant in Rewa, Madhya Pradesh was sold for 2.97 Rs/kWh—less than the average FY 2018-19 price of coal-fired electricity from NTPC (3.46 Rs/kWh, equal to US$0.045/kWh[70]). More than 113GW

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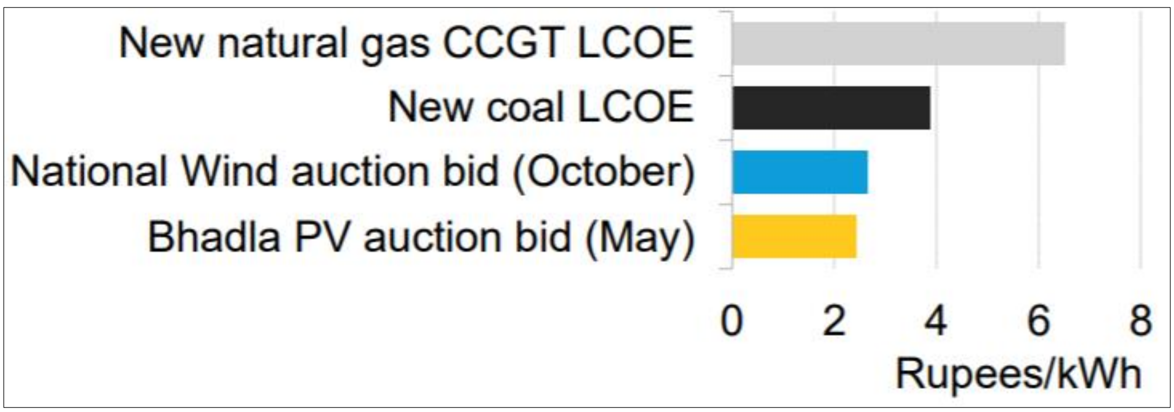
[66] Buckley, T. and Shah, K. IEEFA briefing note: India's electricity sector transition still on track despite a weak FY2018/19. April 25, 2019.
[67] Buckley, T. and Shah, K. IEEFA India: New record with renewable energy installations 40 times higher than thermal. January 29, 2019.
[68] Kabeer, N. 50 MW of Solar Projects to be Developed in Pavagada Solar Park at a Tariff of ₹1.24/kWh. *Mercom India*. February 21, 2019.
[69] Sources: (1) Dutta, S. India solar power tariff finds new floor at Rs 2.97. *The Times of India.* February 10, 2017; (2) Chandrasekaran, K. Solar tariffs once again hit all-time low of Rs 2.44 a unit at SECI auction. The Economic Times. July 3, 2018.
[70] All USD figures in this paragraph were obtained using the exchange rate on Oanda as calculated April 16, 2019.

of India's installed coal capacity is selling electricity at prices greater than 3 Rs/kWh and older coal plants (older than 25 years) have average electricity prices above 4 Rs/kWh.[71]

A 2017 power sector briefing from Greenpeace estimated that Indian electricity customers could save up to 54,000 crores (US$8.3 billion) annually by replacing the most expensive coal plants with solar and wind (they assume average renewable prices of 3 Rs/kWh—a conservative estimate, given recent trends).[72] As such, replacing the nation's most expensive coal plants with renewable sources has the potential to save Indian electric consumers money and generate cost savings for the electric system.

A recent Bloomberg Financial assessment takes this data one step further, showing that new utility-scale solar and wind in India is less expensive than new gas and coal (Figure 12).

## Figure 12. Bloomberg New Energy Finance: Indian 2017 Auction Prices and Assessed LCOEs




*Source: Reproduced from Bloomberg New Energy Finance.*[73]

[71] India CEA. Executive Summary on Power Sector—Rate of Sale of Power. FY 2010-11 through FY 2017-18.
[72] Greenpeace. UNCOMPETITIVE: Coal's coast disadvantage grows as renewable tariffs plummet. Power Sector Briefing. December 2017.
[73] Bloomberg New Energy Finance. Accelerating India's Clean Energy Transition. November 28, 2017.

# Conclusion

Threats to the financial viability of coal-fired power plants in India include overbuilt coal capacity and declining plant load factors, large amounts of new, lower-cost renewable capacity, and water availability-related issues. These risks have already reduced coal power generation in the country and are expected to grow steadily worse in the years ahead.

We recommend the following policies as a means of ensuring that the problems facing the Indian coal power generation sector do not undercut the long-term growth of the country's economy:

1. India should adopt a policy of no net new coal-fired power generation beyond what is already under construction.

2. Plants under construction should be reviewed for possible cancellation.

3. An economic assessment should be conducted of the nation's oldest coal-fired power plants to determine their financial viability, including the cost of retrofitting with pollution controls. A phased, end-of-life closure plan needs to be prepared and implemented.

4. Coal capacity in the most drought-stricken areas—estimated to total 37GW—must be addressed as a priority. This capacity should be replaced with low-cost renewable solar and wind resources. Accelerated investment in interstate grid transmission capacity expansion and modernization is required to build national grid reliability and accommodate low-cost but variable renewable energy.

With a growing population and economy, India needs to pay greater attention to its water resource problems in order to guarantee long-term supply availability for all.

# About IEEFA

The Institute for Energy Economics and Financial Analysis conducts research and analyses on financial and economic issues related to energy and the environment. The Institute's mission is to accelerate the transition to a diverse, sustainable and profitable energy economy. www.ieefa.org

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The Applied Economics Clinic (AEC) is an independent, 501(c)(3) non-profit consulting group that provides expert testimony, analysis, modelling, policy briefs, and reports for public interest groups on the topics of energy, environment, consumer protection, and equity, while providing on-the-job training to a new generation of technical experts. https://aeclinic.org/

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