HEINRICH BÖLL STIFTUNG
INDIA

ENERGY-WATER NEXUS

A study on Water and Coal Power Linkages in India

A study by Vasudha Foundation

VASUDHA FOUNDATION
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"Energy-Water Nexus: A study on Water and Coal Power Linkages in India"
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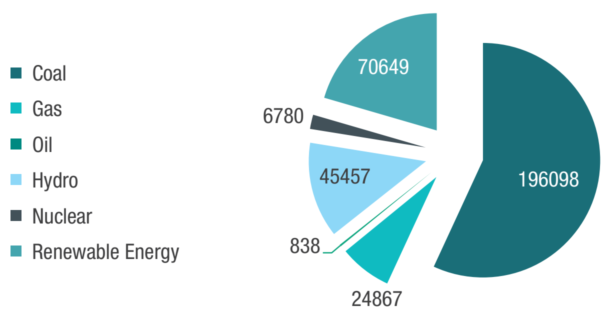
I

INTRODUCTION

Thermal Power is the major source of electricity in India. As on September 2018 and according to the Central Electricity Authority (CEA), conventional sources of energy (i.e., coal, diesel and gas) contribute to 64.30 percent (221803 MW) of India's total electricity generation installed capacity, with coal based thermal power plants alone contributing 56.90 percent, accounting for 196098 MW.

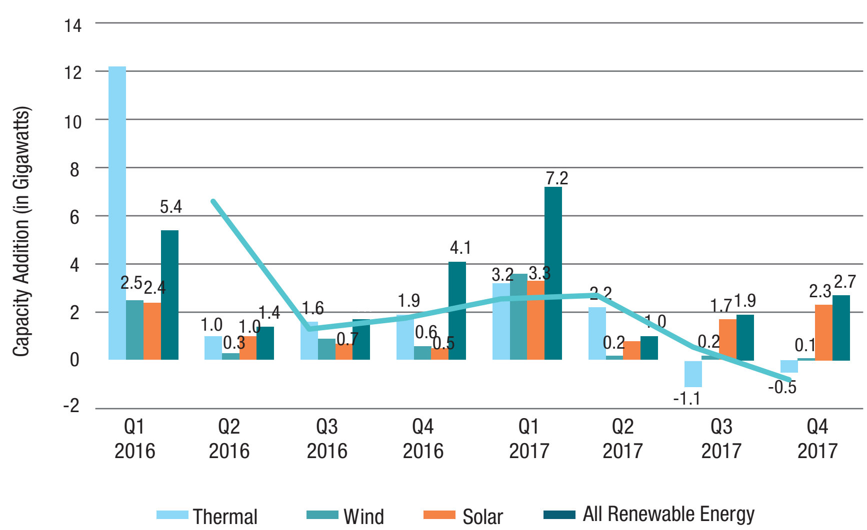
Electricity Generation (Installed Capacity) in India as on 31st August 2018 (in MW)



In spite of emerging growth in renewable energy sources such as solar and wind power, particularly in the last three years, coal power plants still remains the major contributor to the power demand in the country. The adjacent graph shows the trend of source wise capacity addition in the electricity generation mix of India.

Notwithstanding the trend of growth in renewable energy electricity generation, the Third National Energy Policy[1] (NEP) released in June 2017 by the NITI Ayog, also reaffirms that the predominant focus will be on "enhancing coal production". The report forecasts a net expansion of 57 GW in thermal power capacity in the decade to 2016-27, while also setting the target for renewable energy capacity addition to 175 GW by 2022. Interestingly in 2017, a few coal power plants closed down their operation, and therefore, there is a negative growth in coal power plant capacity addition. One of the main reasons for the shutdown were age and in the case of Delhi, due to pollution.

Source wise Electricity Generation Capacity Addition in India 2016 and 2017 - The Trend

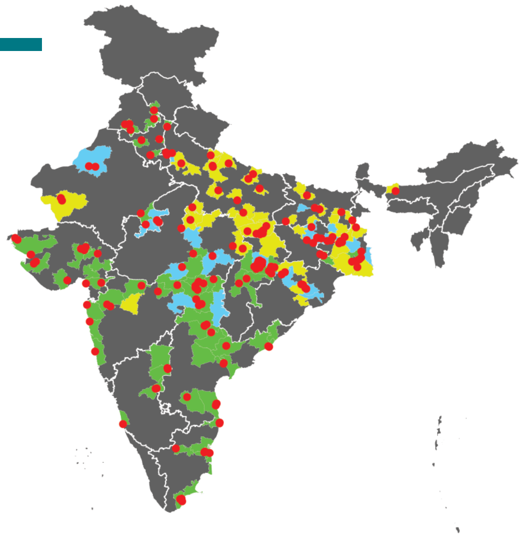


[1]National Energy Policy, June 2018, NITI AYOG, Government of India. (Online source)
Link: http://niti.gov.in/writereaddata/files/new_initiatives/NEP-ID_27.06.2017.pdfas retrieved on 16th October 2018

The explanation and rationale usually given for rapid expansion in Coal is to accomplish the goal of universal energy access across India. However, there is enough evidence to show that this rapid growth in expansion of coal power plants has not necessarily lead to rapid gains in bringing energy access to all people.

As can be seen from the maps below, areas / districts / states, that have large concentration of coal power plants, do not necessarily have 100 percent electrified households. On the contrary, many of these states in fact, have a large number of un-electrified households.

Distribution of Coal Power Plants and Energy Access in India

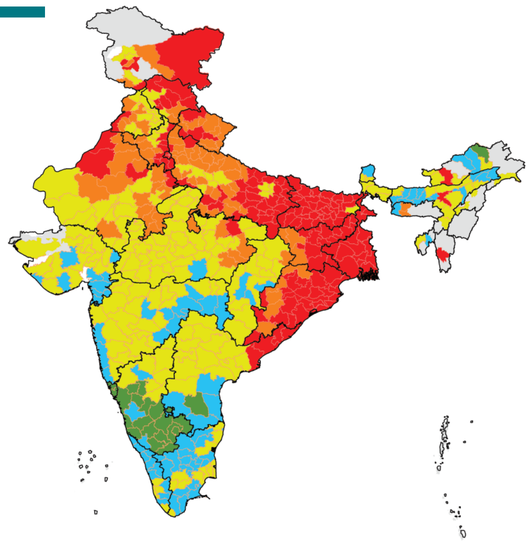


Data compiled only for districts where coal power plants are located.

Further in recent times, a number of factors have significantly impacted India's power sector. Close to 40 GW of commissioned and under construction coal power plants are already in the category of "non-performing assets". One of the significant factors that has resulted in the coal power plant being "stressed" is amongst other, due to "unavailability of raw water".

In the backdrop of this, it is also pertinent to look at the country's water levels. Most parts of India have been predominantly drought prone in the last few years. This year alone, as of the week ending September 26th 2018, out of 718 districts in India, 251 districts, i.e. around 35 percent, have noted "large" rainfall deficit[2] as per Indian Meteorological Department[3].

Extent of Dryness and Wetness in Districts across India (Jan to March 2018)



Source: Adapted from IMD Data

Amongst the states badly hit, by drought due to deficient rainfall, Karnataka and Maharashtra reported 23 out of 30 districts and 32 out of 36 districts as being drought declared, respectively.[4]

Based on the above, this report, primarily delves deep into the current impacts of water shortage on electricity generation by coal power plants . And, further analyses how a business as usual projection on water scenario could potentially impact coal power plants that are in various stages of construction and commissioning, particularly in drought prone areas of India. As is described in the subsequent sections of this report, electricity generation through coal power plants is a "Water Intensive" process.

[2] Bhaskar Tripathi, 26th September 2018, The Quaint. Available online at: https://www.thequint.com/news/india/drought-like-conditions-in-37-districts-in-indiaas retrieved on 26th October 2018.
[3] Indian Meteorological Department, Customized Rainfall Information System (CRIS)
Hydromet Division, Available online at: http://hydro.imd.gov.in/hydrometweb/(S(ukdm4l45msqytd2y3hkjro45))/landing.aspx as retrieved on 26th October 2018.
[4] Times of India, 14th September 2018, Rainfall Deficit 23 districts of Karnataka declared drought struck. Available online at: https://timesofindia.indiatimes.com/city/bengaluru/rain-deficit-23-districts-of-karnataka-declared-drought-hit/articleshow/65803488.cms as retrieved on 26th October 2018.

II

METHODOLOGY

While this report only analyses the water-coal power plant linkages, the starting point of the exercise was the creation of a comprehensive inventory of all sources of electricity generation in India, mapped against wide range of parameters that include environmental, social aspects, performance indicators, geographic indicators and specific to this report, the water parameters. The inventory, which is a work in progress document, can also be accessed from the website, www.vasudha-emi.in.

Specific to the water parameters, this report is primarily based on analyzing the following parameters -

a) Mapping of the geographic location of all existing and proposed coal power plants in India.

b) Assessing the water consumption of coal power plants, in some cases, directly from data and information reported by the companies and in some cases, derived based on the size of the power plant, boiler type etc.

c) Mapping of water linkages of power plants. Primarily this entailed getting information of where exactly the coal power plant is sourcing its water requirements - wether it is a reservoir or river basin or ground water or piped water supply or sea water.

d) Mapping of the Ground water levels in regions where the coal power plants are located or proposed. This information was for both water table levels, pre-monsoon as well as post-monsoon and accessed from the Central Water Commission(CWC).

e) Mapping of coal power plants located in and around river basins.

f) Projecting water levels under various scenarios for a period of 2020, 2030 and 2040, based on both information provided by the Central Water Commission as well as using the aqueduct tool of the World Resources Institute(WRI).

All the information related to the above parameters has been largely sourced from Government of India databases, namely, the Central Electricity Authority (CEA) on power plant data and information, the Ministry of Environment, Forests and Climate Change (MoEFCC) for accessing information on Environment Impacts Assessments of Coal Power Plants and their Terms of Reference, that has crucial information on water linkages, water usage etc. We have also referred to the Central Water Commission for information on ground water levels and the River Basin Authority for information on river basin levels.

III

PERFORMANCE OF COAL POWER PLANTS

Exploring the Role of Water in Impacting Performance of Operating Coal Power Plants in India

Some of the key indicators of performance of coal power plants is the "Plant Load Factor". The "Plant Load Factor" that is also known as "Capacity Utilization Factor", is the measure of "Average Capacity Utilization of a Power Plant". To simplify it, it is a measure of how many hours and days a power plant is able to operate. Normally, a power plant is expected to operate 24 hours, for most days in a year, with the exception of a few days of planned shut down for routine maintenance.

The Plant Load Factor of India's coal power plants has been showing a steady decline since 2009-10. The following table and graphs show the national average PLF of coal power plants from 2009-10.

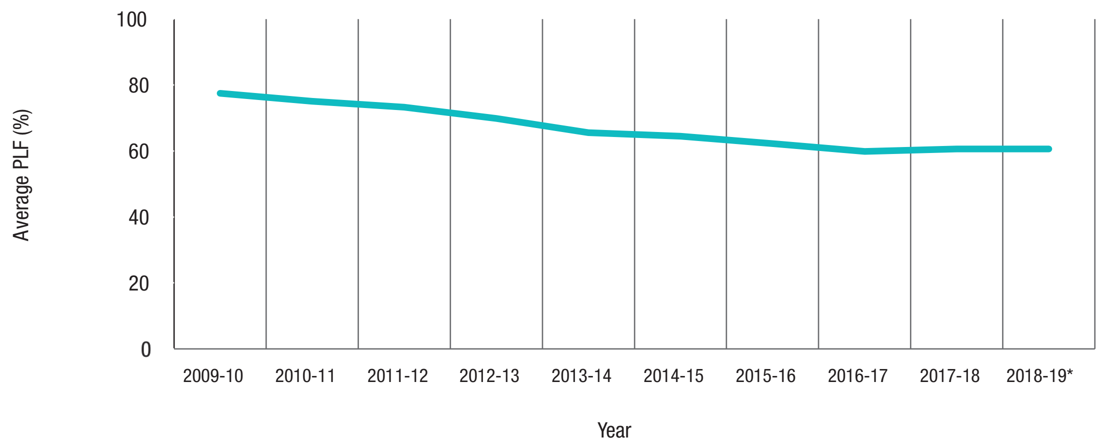
PLF Trends of Coal Power Plants in India[5]

Year	Average PLF (All India)
2009 - 10	77.50%
2010 - 11	75.10%
2011 - 12	73.30%
2012 - 13	69.90%
2013 - 14	65.60%
2014 - 15	64.46%
2015 - 16	62.29%
2016 - 17	59.88%
2017 - 18	60.67%
2018 - 19*	60.59%

Upto August 2018

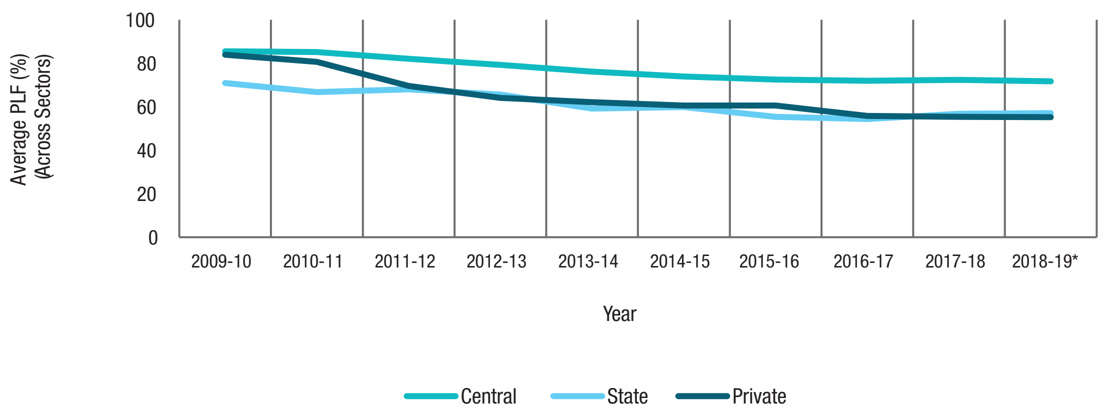
[5] Vasudha Foundation Energy Mapping Initiative Inventory and corroborated by Ministry of Power – Power Sector at a Glance(https://powermin.nic.in/en/content/power-sector-glance-all-india)

Trends of PLF of Coal Power Plants in India (2009-10 to 2018-19)[6]



The sector-wise performance of coal power plants measured by PLF in India, indicates that the central sector, which primarily comprises of power plants owned and operated by the central government power companies such as, National Thermal Power Corporation Limited(NTPC Ltd.) have been performing the best. While, power plants owned and operated by the state government enterprises have had a relatively low level of capacity utilization. The private sector in the initial years of 2009-10 and 2010-11 performed nearly as well as the central sector power plants. But over the years, their performance as indicated by PLF has declined considerably.

Sector Wise Performance of Coal Power Plants (PLF) 2009-10 to 2018-19[7]



There were 77 Coal Power plants with a cumulative installed capacity of 11899.5 MW operating at a PLF of less than 20 percent. Furthermore, 74 coal power plants with a cumulative installed capacity of 20787.5 MW were operating at a PLF of between 20-50 percent. See Annexure for a full list of coal power plants as per PLF.

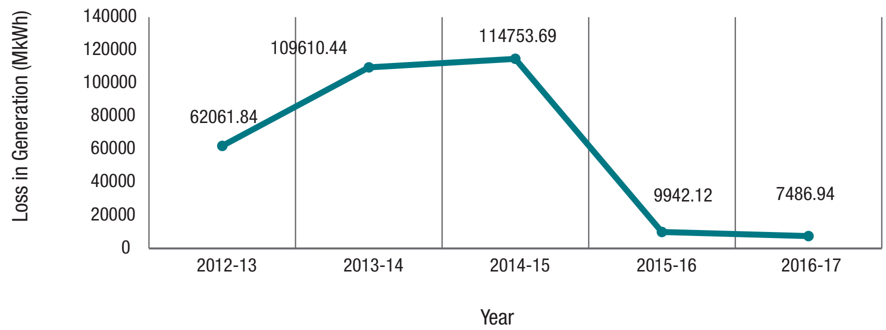
[6] Source: Vasudha Foundation Energy Mapping Initiative Inventory and corroborated by Ministry of Power – Power Sector at a Glance (Available at: https://powermin.nic.in/en/content/power-sector-glance-all-india)
[7] Source: Vasudha Foundation Energy Mapping Initiative Inventory and corroborated by Ministry of Power – Power Sector at a Glance (https://powermin.nic.in/en/content/power-sector-glance-all-india)

There are number of reasons for power plants not operating to their full capacities. Our analysis indicates that the "less than optimum performance of power plants" across the time period between 2009 and 2018 is because of 5 major reasons. These are mainly, *'shortage of coal availability', 'financial distress of electricity distribution companies leading to non-purchase of electricity from power generators', 'lack of raw water availability, particularly in power plants located in highly drought prone areas', and in recent times, 'cost competitiveness of renewable energy alternatives' and 'old age of power plants leading to frequent technical break down of power plants'.* In addition to the above reasons, in some parts of India, a few power plants were forced shut down to combat poor ambient air quality.

To corroborate our analysis of drivers or factors responsible for "low performance of power plants", we prepared an inventory of various factors that have contributed to what is called as "Forced Outages" of power plants, which is compiled by the Central Electricity Authority. We categorized the reasons for "Forced Outages" in to the following categories, namely, "technical", "economical reasons", "reserve shut down", "coal shortage" "raw water unavailability" and "low demand".

In the year 2014-15 alone, the loss in generation was 114,753.69 Million kWh, or equivalent to 14.25 percent of the total generation that year. The graphs below show the trend of loss in generation due to various reasons.

Cumulative loss in Generation due to Forced Outages (All Reasons)

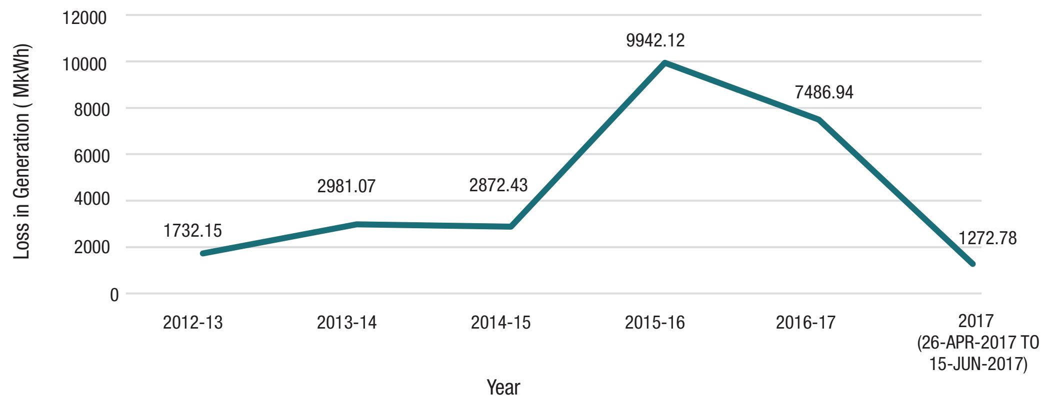


As can be seen from the graph, the years 2015-16 and 2016-17 showed a relatively lower closure of coal power plants due to Forced Outages, largely because, one of the key issues that the new Government which came to power in 2014 looked into, in the electricity sector, was to address the shortage of coal supply and also ensure that electricity distribution utilities were purchasing power from generators. Further, the Government had also prioritized on "Electricity Supply" to all villages and therefore, that period also saw an increase in demand for electricity, mainly due to new electricity connections.

Now coming specifically to water, our analysis shows that water is one amongst the main drivers for impacting the performance of coal power plants in India.

As can be seen in the graph below, between 2012 and 2017, water scarcity was reportedly responsible for coal power generation losses of 5 billion kWh a year, with strong annual variation across years. In 2015-16 and 2016-17, India experienced particularly severe drought, affecting water availability to coal power plants.

Loss in generation due to raw water unavailability (2012-13 to 2017) (in Million kWh)



The water scarcity in India was highest in 2015-16 and therefore, that year saw a huge rise in loss of generation due to lack of availability of raw water. While 2016-17 was also a bad year from a “water perspective”, it seemed slightly better than the preceding year. The data for 2017 is only from April to June and therefore is not a complete picture.

In line with the above trend, the following coal power plants were shut down for various periods of time from of 1st July 2016 to 25th April 2017 due to water shortage.

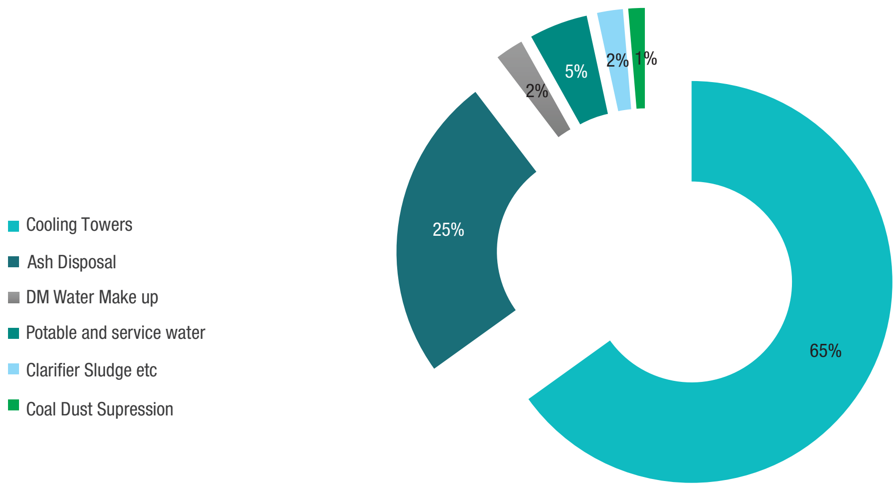
Loss in Generation due to Water Shortage, From 1st July 2016 to 25th April 2017

S.No.	Name of Power Plant	Owner	Capacity (MW)	State	Outage Days	Loss of Generation (MUs)
1	Simhapuri TPS	SEPL	600	Andhra Pradesh		
	Unit 2		150		112	322.56
2	O.P. Jindal or Tamnar I Project Thermal Power station	Jindal Power Ltd.	1000	Chhattisgarh		
	Unit 4		250		10	49.42
3	Ratija Thermal Power Station	SCPL	100	Chhattisgarh		
	Unit 1		50		22	20.95
4	SVPL Thermal Power Station	SVPPL	63	Chhattisgarh		
	Unit 1		63		30	35.99
5	Essar Power Salaya Ltd or Salaya Thermal Power Plant	EPGL	1200	Gujarat		
	Unit 1		600		13	148.45
6	Raichur Thermal Power Station	Karnataka Power Corp. Ltd.	1720	Karnataka		
	Unit 7		210		36	144.25
7	Bellary TPS	Karnataka Power Corp. Ltd.	1700	Karnataka		
	Unit 1 Unit 2		500 500		34 6	321.87 62.33
8	Torangallu Thermal Power Plant	JSW Energy Ltd.	690	Karnataka		
	SBU I - Unit 1		130		3	14.99
9	Tirora thermal power station	Adani Power Co. Ltd.	3300	Maharashtra		
	Unit 1 Unit 2 Unit 5		660 660 660		15 14 15	187.01 178.46 190.08
10	Parli Thermal Power Station	Maharashtra State Power Generation Co. Ltd.	1380	Maharashtra		
	Unit 3 Unit 4 Unit 5 Unit 6 Unit 7 Unit 8		210 210 210 250 250 250		289 174 174 107 98 89	1165.25 701.57 701.57 513.17 470.4 426.04
11	Sterlite (Jharsuguda) Thermal Power Plant	Sterlite Energy Ltd.	2400	Odisha		
	Unit 1 Unit 2		600 600		2 84	22.9 963.57
12	Talwandi Sabo TPP	Talwandi Sabo Power Ltd.	1980	Punjab		
	Unit 1 Unit 3		660 660		34 8	426.08 106.97
13	Tuticorin Thermal Power Station (TPS)	Tamil Nadu Generation & Distribution Corp. Ltd.	1050	Tamil Nadu		
	Unit 1 Unit 2		210 210		33 45	131.62 181.44
		TOTAL				7486.94

To put this in perspective, power production by coal burning is a water-intensive process. Since, coal power plants use water for a wide range of processes, such as for the boiler, cooling system, and coal and ash handling, out of which, the major water consuming process being cooling systems.

The following graph gives an indication of the water requirement for various operations of a coal power plant.

Estimated Process Wise Water Consumption in Power Plants per hour (m^3/MW)[8]



As can be seen from the graph, the total consumption of water in power plants from a technical perspective is currently **4m³/MWh**. The CEA assumes that the water for ash handling is usually tapped from the Cooling Water Pump system and hence should not be taken as additional water consumption.

Notwithstanding that, as per Environment (Protection) Amendment Rules, 2017, notified by the Ministry of Environment, Forest and Climate Change (MoEF&CC), all new plants installed after January 1, 2017, should not consume more than 3 m^3/MWh power produced. This would mean that coal power plant will have to reduce their water consumption or resort to recycling of their water in order to meet with the new rules of MoEFCC.

[8]Source: CEA Report on Water Consumption of Coal Plants (http://www.cea.nic.in/reports/others/thermal/tetd/min_of%20water_coal_power.pdf)

IV

WATER AVAILABILITY SCENARIO AND POWER PLANTS IN INDIA

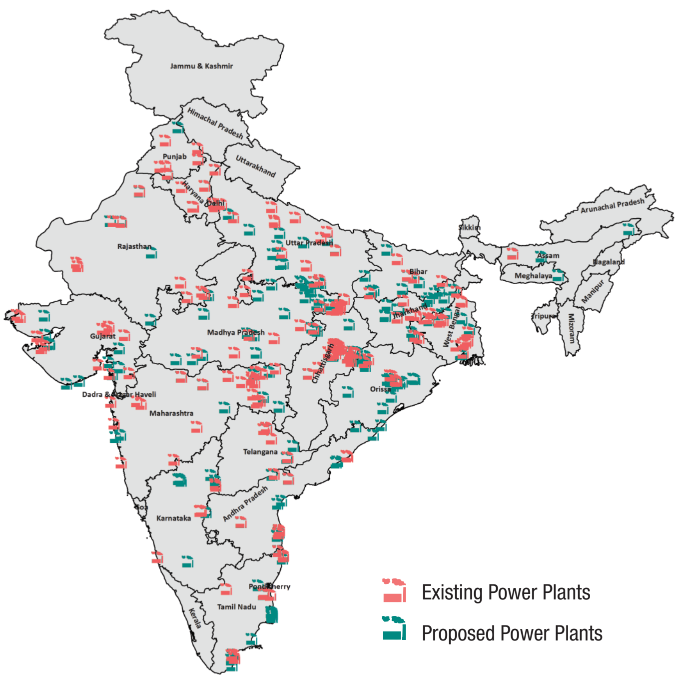
i. Background

As per the Vasudha Inventory of coal power plants in India, there are 720 coal power plant units with a total installed capacity of 203322 MW spread across India as on 30th June 2018 with 196098 MW of operational coal power plants.

Further, our inventory also maps coal power plants that are in the pipe-line. These primarily include coal power plants that have their Environmental Clearances (EC) and Terms of Reference (ToR) approved by the appropriate authorities. In our inventory of power plants that are in the pipe-line, we have 445 coal power plant units with a cumulative proposed capacity addition of 271882 MW.

The map below shows the location of both the existing and proposed coal power plants in India.

Existing & Proposed Coal Power Plants in India



Further, in addition to the proposed coal power plants that have their ECs and ToRs approved, there are a number of coal power plants that are awaiting ECs and approvals for their respective ToRs. The cumulative capacities of such power plants could be anywhere in the region of upwards of 300,000 MW[9].

Even conservatively, adding just the operational coal power plants with the coal power plants that have their ECs and ToRs, and assuming that all those proposed plants will be operational soon, there is likely to be 467,980MW installed capacity of coal power plants.

Further, as per the estimates of the Centre of Science and Environment, report published in 2015[10], Indian coal power plants, withdraw 22 Billion Cubic Meters (BCM) of water for its operation, which is over half of India's estimated domestic water requirement. This would impact the requirement of water for domestic consumption and for irrigation purposes.

In view of this, we analyzed both ground water level data for the current period as well as projected ground water levels by the Central Water Commission as well as river basin levels and projected river basin levels at varying points of time. This analysis was done primarily to look at water availability and potential impacts of water shortage on power plant operations.

[9] Approximation based on scanning ECs and ToR applications for power Plants with MoEFCC

[10] https://www.cseindia.org/indias-first-ever-environmental-rating-of-coal-based-power-plants-finds-the-sectors-performance-to-be-way-below-global-benchmarks-5685

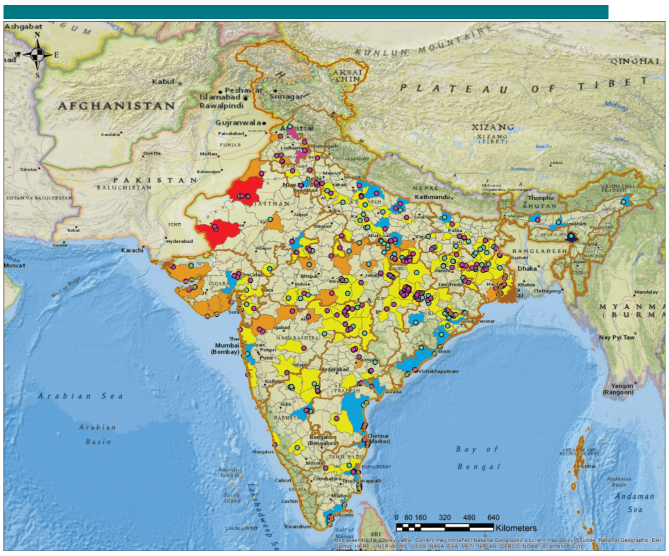
ii Overview of the Ground Water Level Situation – Ground Reality in India

In order to assess the ground water level situation in India, we referred to the data published by the Central Ground Water Board (CGWB), in their annual publication, the Ground Water Year Book.[11]

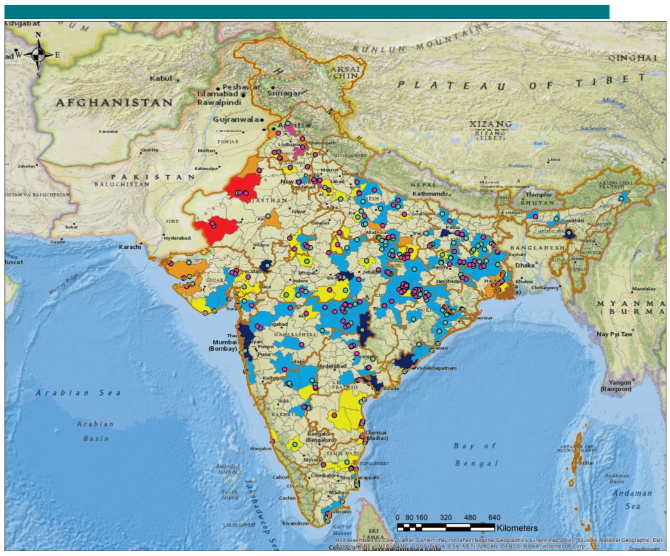
The data was primarily taken for both the pre-monsoon as well as the post-monsoon period for the years 2014-15, 2015-16 and 2016-17. Typically, the data published in the year book is state-wise information and is based on monitoring wells and depth of ground water levels. The pre-monsoon data is collected during the months of March/April/May and the post-monsoon data is collected in the month of November, each year.

Further analysing the pre-monsoon and post-monsoon ground water levels, using GIS data, we mapped the districts where coal power plants are located. The following maps depict the ground water levels for the years, i.e.,2015-16 and 2016-17.

Pre-Monsoon Depth to Water Level (2016-17)



Post-Monsoon Depth to Water Level (2016-17)



Depth To Water Level (m bgl)

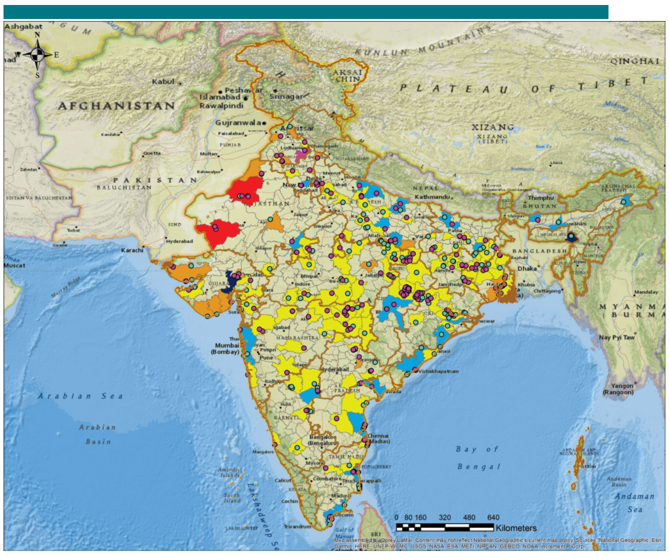
■ 0 to 2 ■ 2 to 5 ■ 5 to10 ■ 10 to20 ■ 20 to 40 ■ >40 □ State Boundary ● Existing Plants ● Proposed Plants

Data compiled only for districts where coal power plants are located.

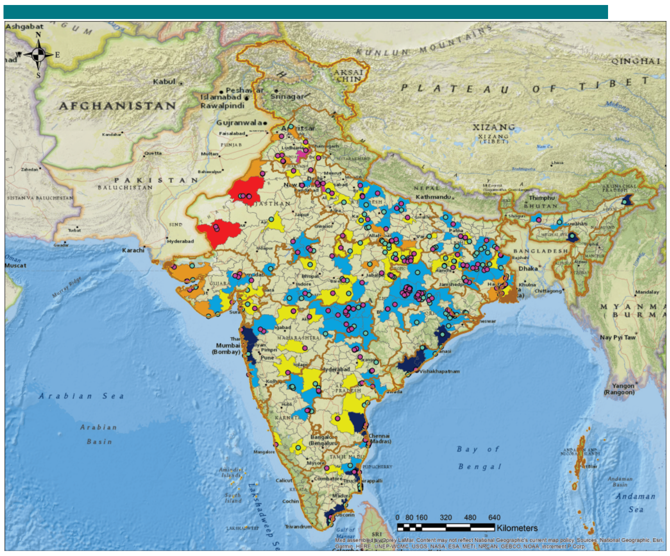
The maps clearly show that ground water levels in the pre-monsoon period for a number of regions are bordering on "drought like" conditions. However, the situation does improve to some extent in the post-monsoon period, though, some areas continue to remain drought prone, particularly in parts of Maharashtra, Karnataka, Tamil Nadu, Gujarat to name a few.

The ground water level situation for the year 2015-16 was similar to 2016-17, as can be seen from the maps below:

Pre-Monsoon Depth to Water Level (2015-16)



Post-Monsoon Depth to Water Level (2015-16)



Depth To Water Level (m bgl)

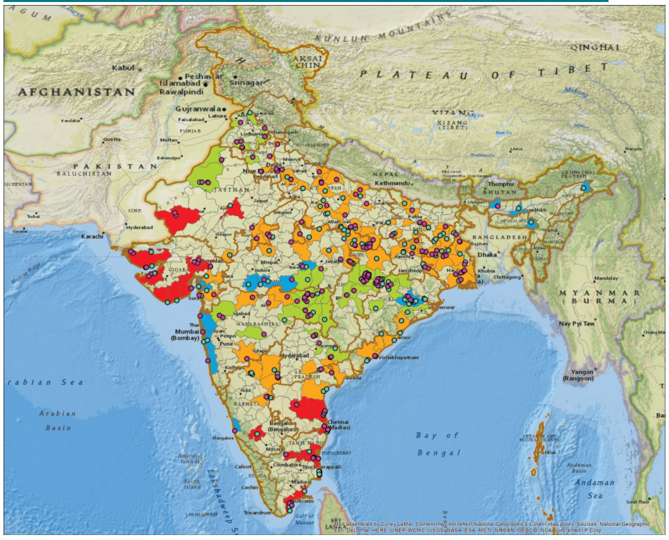
■ 0 to 2 ■ 2 to 5 ■ 5 to10 ■ 10 to20 ■ 20 to 40 ■ >40 □ State Boundary ● Existing Plants ● Proposed Plants

Data compiled only for districts where coal power plants are located.

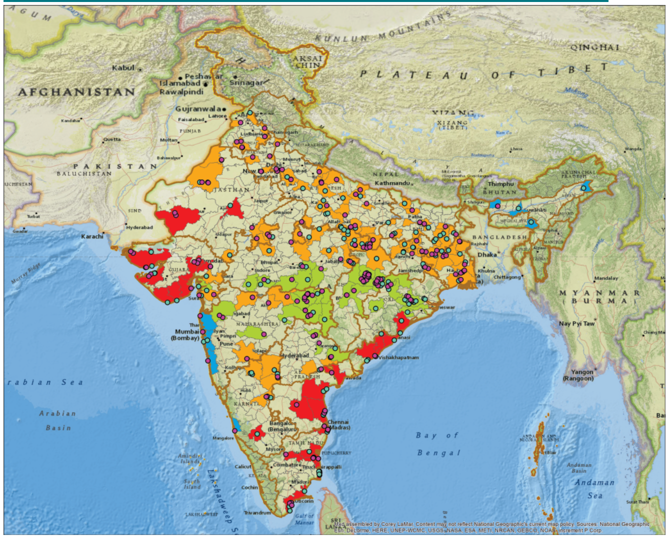
[911] Central Ground Water Board, 2017, Ground Water Book. Link: http://cgwb.gov.in/GW-Year-Book-State.html as retrieved on 8th October 2018

To analyse ground water levels as per CWC projections, we compared the current and projected ground water levels in the districts where the coal power plants are located. The projected ground water levels are for the year of 2025 and 2050.

Water Stress Levels Based On CWC Parameters (2025)



Water Stress Levels Based On CWC Parameters (2050)



Water Stress Levels

Absolute Scarcity (<500m^3) | Scarcity (500-1000m^3) | Stress (1000-1700m^3) | No Stress (>1700m^3) | State Boundary | Existing Plants | Proposed Plants

Data compiled only for districts where coal power plants are located.

As can be seen from the maps, for both the pre-monsoon period and post-monsoon period, there is likely to be a major impact on water availability, particularly in areas where coal power plants are located or would be located, given the plants in pipe-line . There are more areas and regions that are in the category of "absolute scarcity" in 2025 and 2050 than what is seen in the current period. Further, even areas that were in the "no water stress" category in the current period, seem to figure in the "water stressed" category in the future.

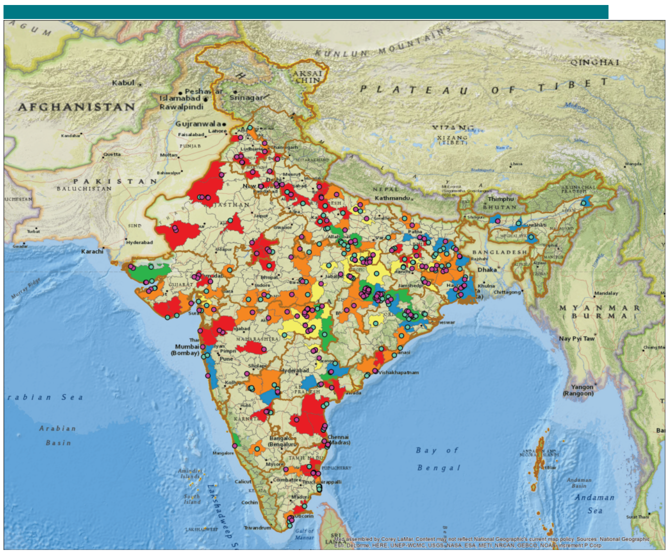
In order to corroborate this information on ground water levels, we used the Aqueduct Tool of the World Resources Institute[12]. The tool primarily helps to project ground water levels under three scenarios, namely, the **"Optimistic Scenario",** where in the temperature rise is between 1.1-2.6°C by 2100; a **"Business as Usual Scenario"**, where in temperature increases between 2.6 – 4.8°C by 2100, relative to 1986-2005 levels and a **"Pessimistic Scenario",** with higher population growth, lower GDP growth and a lower rate of urbanization.

For our analysis on ground water levels, we assumed only two scenarios, namely, the "Optimistic Scenario" and "Business as Usual Scenarios". In our opinion, given actions taken by India to address the issue of Climate Change, a "Pessimistic Scenario" is not likely to occur.

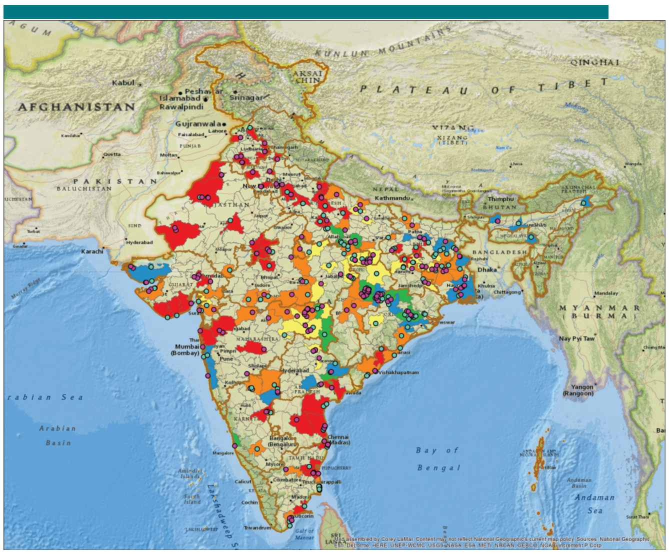
Further, we also looked at ground water level projections for the years 2020, 2030 and 2040.

[12] World Resources Institute. Link: https://www.wri.org/resources/maps/aqueduct-water-risk-atlas

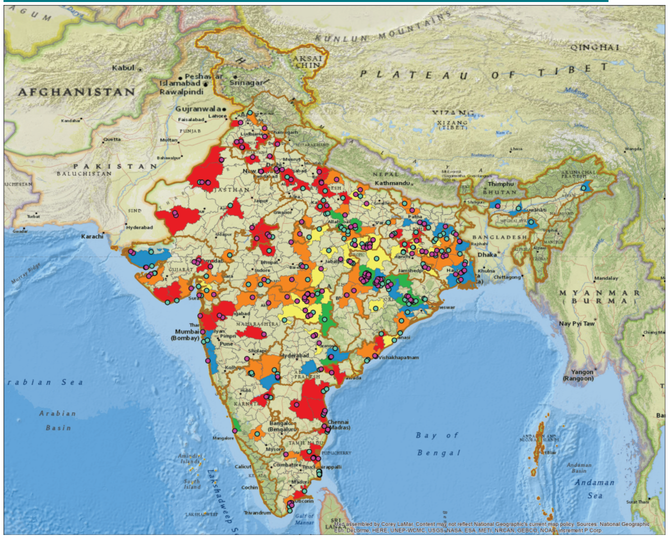
Aqueduct Water Stress Projections 2020 Optimistic (Climate Scenario)



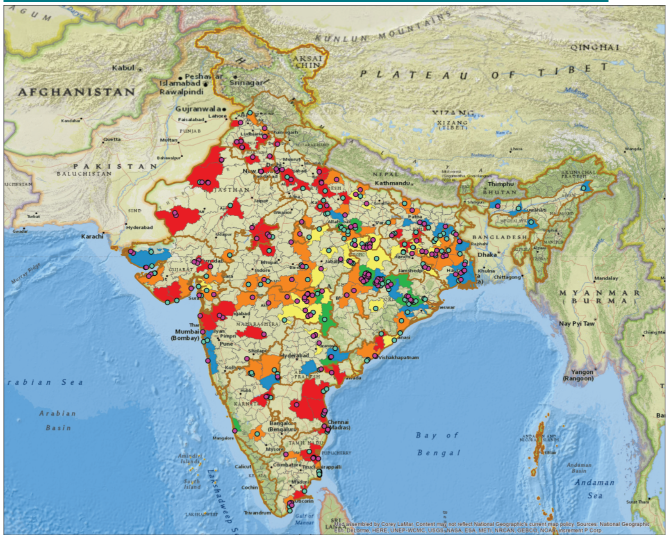
Aqueduct Water Stress Projections 2020 Business as Usual (Climate Scenario)



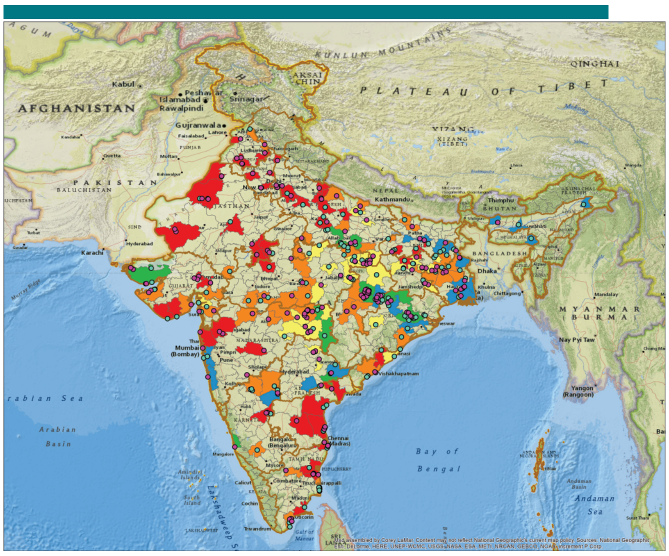
Aqueduct Water Stress Projections 2030 Optimistic (Climate Scenario)



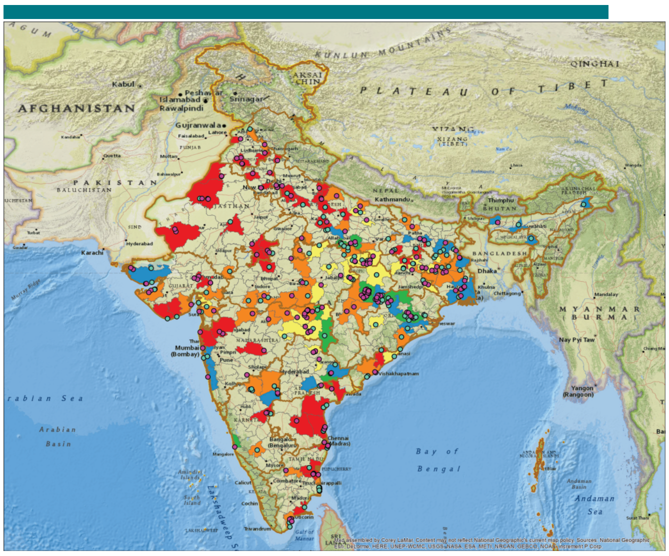
Aqueduct Water Stress Projections 2030 Business as Usual (Climate Scenario)



Aqueduct Water Stress Projections 2040 Optimistic (Climate Scenario)



Aqueduct Water Stress Projections 2040 Business as Usual (Climate Scenario)



Water Stress Levels

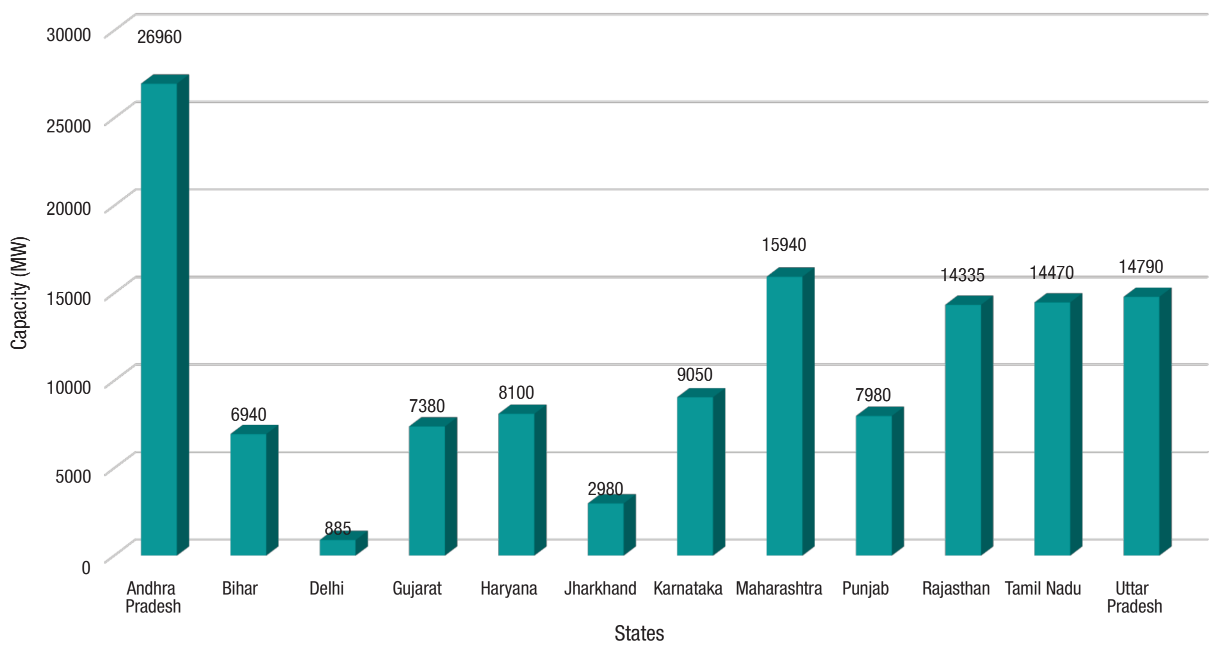
Extremely High (>80%) · High (40-80%) · Medium-High (20-40%) · Low-Medium (10-20%) · Low (<10%) · State Boundary · Existing Plants · Proposed Plants

Data compiled only for districts where coal power plants are located.

The Aqueduct tool's projections on ground water levels for the years 2020, 2030 and 2040 seem to not only corroborate the projections of the CWC, but, it seems to make more dire predictions. Further, one interesting finding is that even at a "optimistic scenario", most regions of India are likely to be in the "Water Stressed" category.

To put this in perspective, we also plotted the cumulative installed generation capacity for both operating coal power plants, plants in the pipe-line and a combination of both, falling in the "Highly Stressed" water zones. The following graphs depict the same, state- wise .

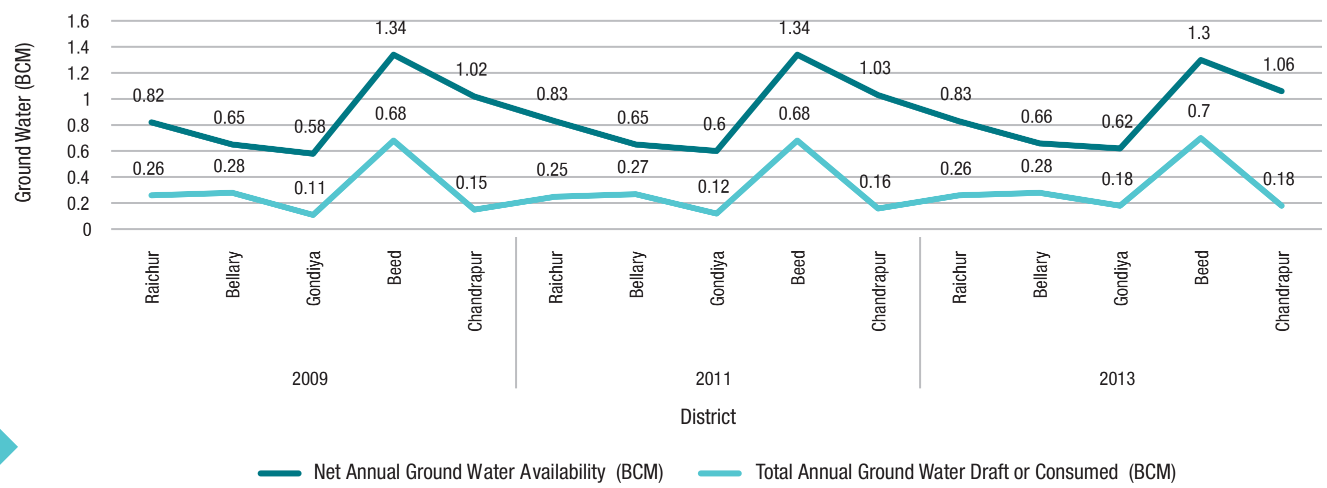
State Wise Total Capacity in MW (Installed and Proposed) Under Extremely High Water Stress Condition in 2020 as per WRI Aqueduct Tool



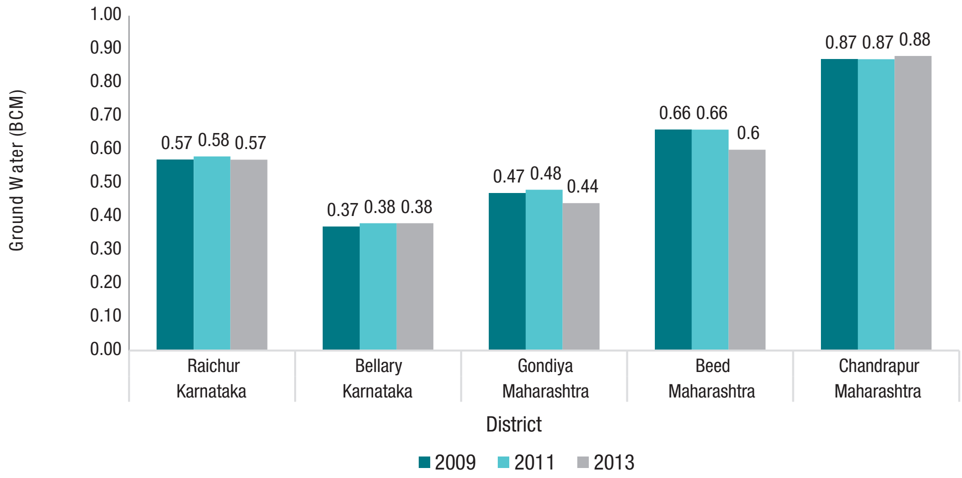
The above graph shows that close to a cumulative of 129,810 MW of both operational coal power plants and coal power plants that are in the pipe-line are water stressed. A back of the envelope calculation indicate that the total loss of generation if these coal power plants are shut down for a year at an assumed PLF rate of 80 percent will be approximately 91 Billion kWh.

We further zeroed down on two states, namely, Karnataka and Maharashtra, where majority of the districts, where coal power plants are located, have already been declared "drought hit" districts. Our analysis was focused on "ground water recharge" and "net water availability" versus "current net withdrawal of water".

Net Annual Ground Water Availability versus Total Annual Ground Water Consumed for Karnataka and Maharashtra (Billion Cubic Meters)



Net Ground Water availability (in Billion Cubic Meters)



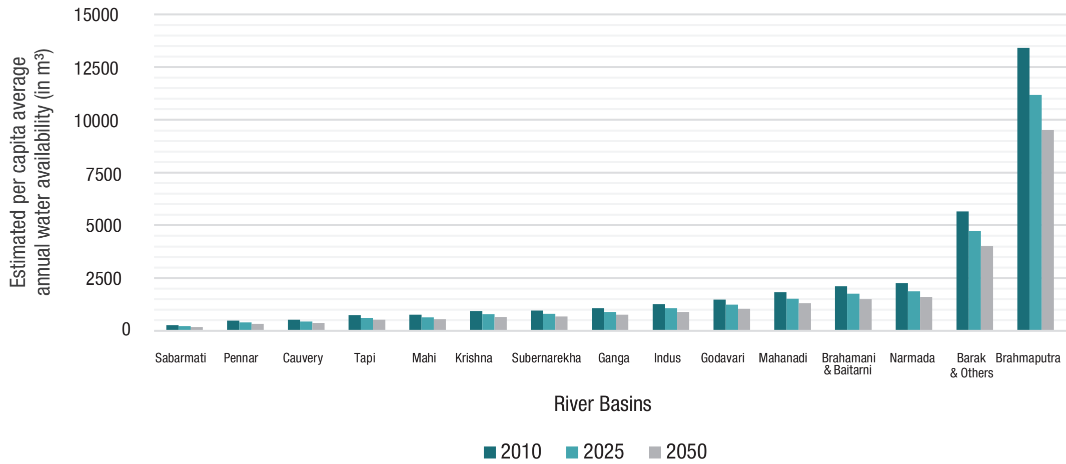
While the graphs above indicates that at the current levels, there is indeed some water availability, the situation is not likely to be the same at growing demand levels of water, due to population growth and industrialization and importantly, setting up of more coal power plants.

iii. Overview of River Basin Water Availability and Coal Power Plants

We took cognizance of the fact that a number of coal power plants access water directly from river basins. We therefore, decided to also map the water availability across a few prominent river basins, particularly those around which coal power plants are located.

The following graph gives an overview of the water availability across major river basins for India. The data for the current period has been taken for the latest available year 2010 and the projected data for the years 2025 and 2050, both have been accessed from the Central Water Commission.

Estimated Per Capita Average Annual Water Availability (m³) in different River Basins during 2010, 2025 & 2050



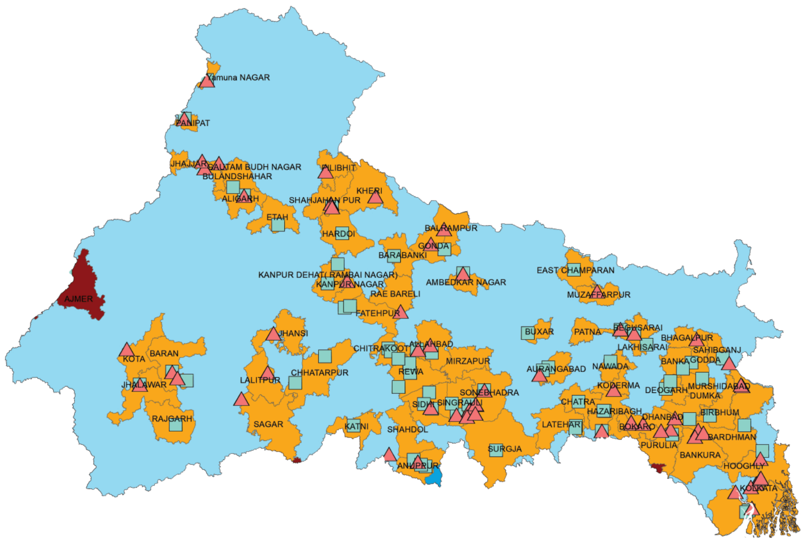
The Brahmaputra river basin clearly has the most sufficient per capita annual average water availability, amongst all the other riven basins. However, this river basin is the home to only one coal power plant, which is the Bongaigaon coal power plant, with an installed capacity of 560 MW. The plant however is up for expansion and the new units that would be added to the coal power plant will total to 3140 MW.

The Ganga basin is the home to a fairly large number of coal power plants, with a cumulative installed capacity of 72,982 MW, comprising of 35.5 percent of the total current installed electricity generation installed capacity of coal power plants. Further the basin is also expected to be the home for an additional capacity expansion of electricity generation of coal power plants to the extent of 104,315 MW.

CWC database for the year 2010 and projections for 2025 indicate that there is likely to be a decline in the per capita water availability in the Ganga river basin from 1061.74 m^3 to 885.27 m^3.

The map below shows the current per-capita water availability for the Ganga Basin (2010 data).

Per Capita Water Availability (2010) of Districts with Coal Power Plants under Ganga Basin

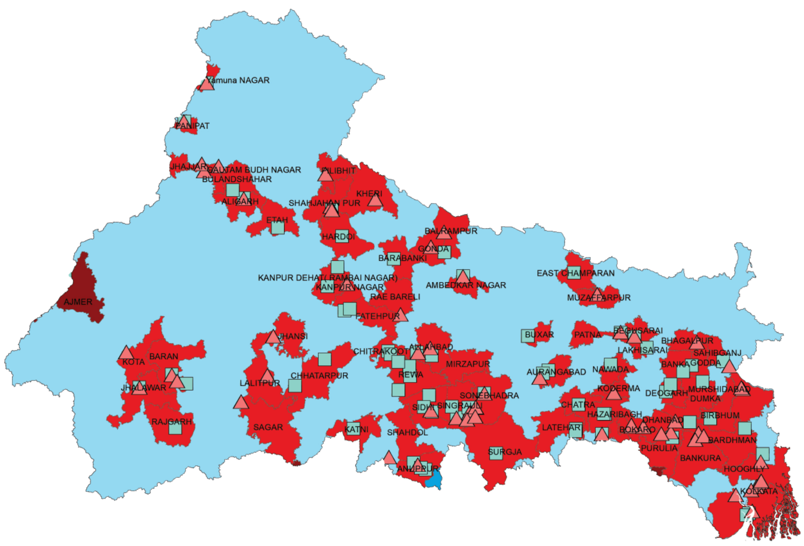


Annual Water Availability (m³)

<700 | 700-900 | 901 -1100 | 1101 - 1300 | >1300 | Ganga Basin Boundary | Existing Power Plants | Proposed Power Plants

The map below shows the projected per-capita water availability for the Ganga Basin in 2025.

Per Capita Water Availability (2025) of Districts with Coal Power Plants under Ganga Basin



Annual Water Availability (m³)

<700 | 700-900 | 901 -1100 | 1101 - 1300 | >1300 | Ganga Basin Boundary | Existing Power Plants | Proposed Power Plants

The comparison of the two maps is self-explanatory. Almost all areas where coal power plants are located or would be located are in the “red” zone as far as water availability is concerned.

iv. Water from Reservoirs

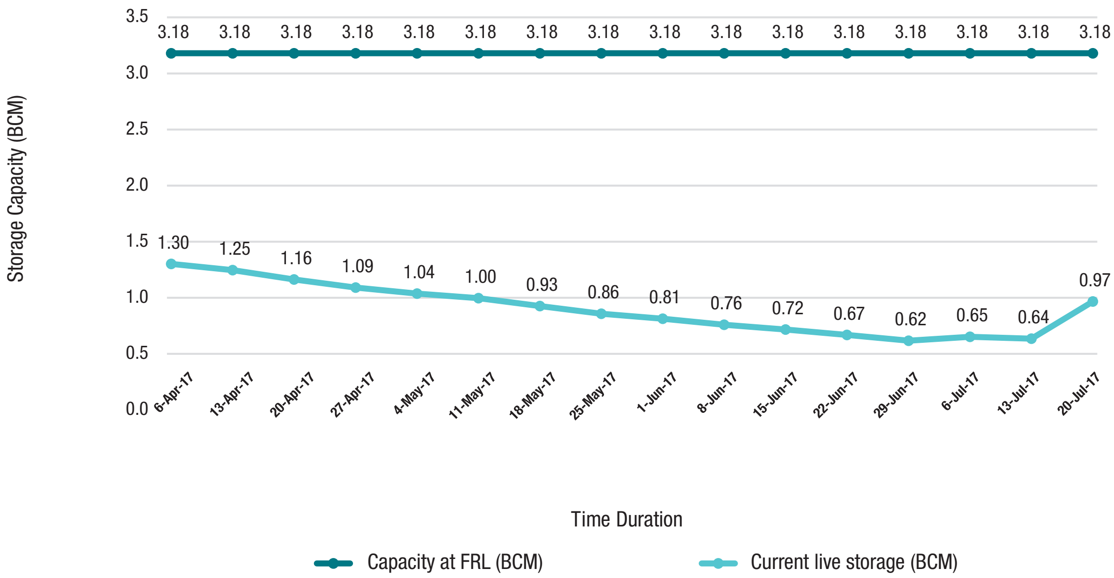
In order to complete the picture, we also looked at coal power plants that have been drawing water from reservoirs. Due to limited availability of information on water levels of reservoirs, we had to rely on information available for 91 reservoirs, where the Central Water Commission monitors the water levels on the constant basis.

One example of an impacted coal power plant due to depleting levels of the Bargi Reservoir, particularly in the summer months is the Seoni Thermal Power Plant.

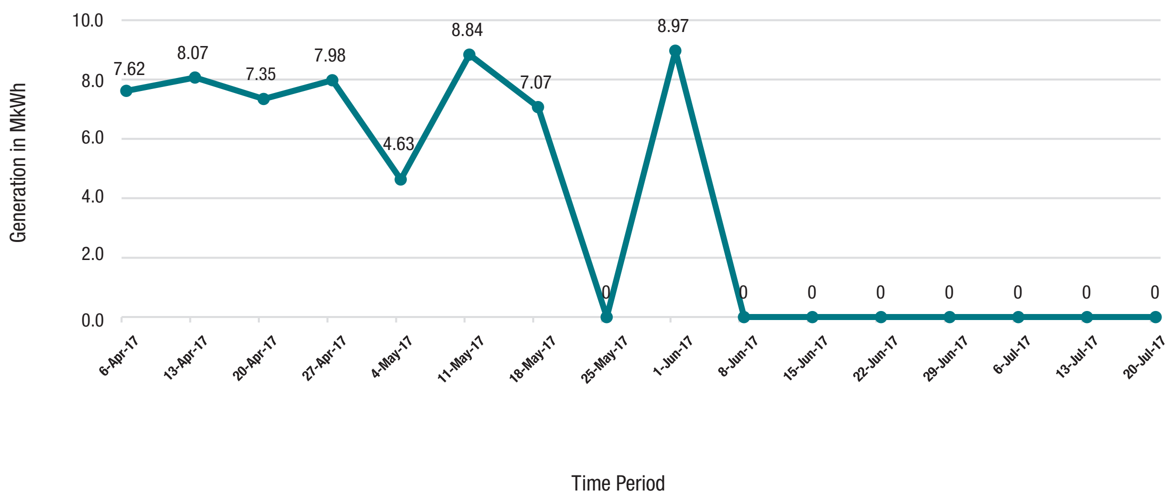
The Seoni Thermal Power Plant located in Madhya Pradesh, with an installed Generation Capacity of 600 MW has had to face shut down, as recently as from 6th April 2017 to 20th July 2017, due to lack of availability of water in the Bargi Reservoir.

The following graphs show the water levels at the Bargi Reservoir versus Daily Generation of electricity from the Seoni Power Plant.

Capacity versus Current Live Storage of Bargi Reservoir (Seoni TPP Sourced Water from Bargi Reservoir)



Daily Generation of Seoni Thermal Power Plant (from 6th April to 20th July 2017)



V

THE HUMAN STORIES

Impact Of Water Scarcity On People

Parli Thermal Power Plant

Parli Thermal Power Plant is located at Parli Vaijnath village in Beed district (Marathwada region) of Maharashtra.

The Parli power plant is a classic case, as the plant continued to be allowed to operate, despite the fact that farmers in the Beed District, faced absolute water distress, with headlines made in 2015 and 2016 reporting suicide of farmers due to failure of crops due to water unavailability.

The following table shows, the unit- wise loss in generation for Parli TPP due to unavailability of raw water required for the functioning of the power plant.

Forced Outage Days and Generation Loss due to Raw Water Unavailability for Parli Thermal Power Station[13]

No. o f Units	Capacity (MW)	2016-17		2015-16		2014-15		2013		2012-13	
		Outage Days	M kWh Loss	Outage Days	M kWh Loss	Outage Days	M kWh Loss	Outage Days	M kWh Loss	Outage Days	M kWh Loss
3	210	289	1165	367	1482	365	1840	365	1840	46	232
4	210	174	702	346	1396	95	477	149	753	124	624
5	210	174	702	345	1393	34	172	175	882	45	227
6	250	107	513	356	1711	32	190	119	715	65	391
7	250	98	470	343	1649	32	193	105	631	43	258
8	250	89	426	0	0	0	0	0	0	0	0

[13]Source: CEA, Forced Outage data as compiled for various years (2012-13 to 2015-160from 'Review of Performance of Thermal Power Station

The Chandrapur Story

Maharashtra has already declared 32 out of 36 districts as drought struck in 2018[14]. This is the second consecutive year that the state is grappling with drought.

Chandrapur district which hosts more than 18 percent of Maharashtra's existing coal power plants is also in the list of drought-struck districts. EMCO Energy Warora TPS, Chandrapur Super TPS, Wardha Warora power plant, Gupta Energy TPP are coal power plants located in the district of Chandrapur.

The Bhadravati power project and Ghughus Power Plant, which are in the pipe-line, are likely to add another 1860 MW to the existing capacity. Most of these power plants source water from the Wardha river and Erai Dam, with their linkage to the Godavari river basin. The CWC projections for Godavari river basin indicate a decline in the estimated per capita average annual water availability for the years 2025 and 2050. The future looks dismal, for an already water stressed situation that the communities are facing.

The Vasudha Team visited Chnadrapur and Wardha districts and primarily the villages of Baranj and Sindhara, in order to understand the ground reality of "water scarcity" in the region and to capture voices from the ground on the impacts of water shortage on their day to day living and livelihoods.

The community members mentioned that for the longest period ever, they did not have drinking water and were dependent on water tankers. Handpumps, wells and other sources had run dry for some time now. When asked about the water source, people mentioned that the largest dam Erai, was built by the plant's implementing agency and hence the water was primarily used for consumption of the power plant. Further, they added that the water quality in the region has also been impacted due to water pollution.

People also opined that their region, that people are no longer able to cultivate their fields. They added that a few years back, Chandrapur was an agricultural district, with, wheat, jowar, paddy, pulses and cotton being the major cultivated crops.

In their view, the reasons for decline in agricultural productivity was largely due to change in the land use pattern, with large tracts of land diverted for mining. Further, land was also acquired for the power plants and allied industries.

The Vasudha team also met with Dr. Yogesh Dudhapachare, Professor of Geography at the Janta College, Chandrapur. He provided us insights on the Land Use Change Patterns and also shared with us a paper he authored on the decline of agricultural productivity due to TPPs in Chandrapur district[15], region. The paper mentions, that 14 percent of agricultural land was diverted for other usage between 1971 to 1991.

Also, the paper cites that the ground water resources are depleting every year and Erai dam, with 225 million cubic meters capacity[16], is primarily diverted to the Chandrapur Super Thermal Power Plant. Further, CGWB report reveals that between 2002 to 2011, there was a decrease in the average annual rainfall as compared to the normal annual rainfall. This has restricted the water usage for purpose of irrigation, thus impacting the crop productivity.



To conclude, it is evident from both the Parli and Chandrapur case studies that there is a growing competing demand for water, and conflicts between industrial water use and domestic water use and water for agriculture. With more coal power plants being added, coupled with the fact that all projections on future water availability, indicate that India's water situation will worsen, such conflicts between industrial water consumption and domestic and agricultural water consumption is bound to increase.

[14]Hindustan Times, Faisal Malik, 16th October 2018. Maharashtra: 32 districts face drought, government lists 179 tehsils for verification. Available online: https://www.hindustantimes.com/mumbai-news/maharashtra-32-districts-face-drought-government-lists-179-tehsils-for-verification/story-ofSgFNzDCPmYBI4AWuBmzH.html as retrieved on 25th October 2018.
[15]Dr Y Y Dudhapachare, February 2012, Cumulative Agriculture Impact Assessment of the Upcoming Thermal Power Plants in Chandrapur districts in Maharashtra., Review of Research, Volume 1, Issue V.
[16]2013, Ground Water Information Chandrapur District, Maharashtra, Available online at:http://cgwb.gov.in/District_Profile/Maharashtra/Chandrapur.pdf as retrieved on 26th October 2018.

VI

CONCLUSION AND RECOMMENDATIONS

As per the Parliamentary Standing Committee on Energy Report, of March 7th, as on March 2018[17], India already had close to 40 GW of "Stressed Assets" in the electricity sector, amounting to Rs. 37,941 Crores. These "stressed assets" have turned into "non-performing assets", a terminology used by banks for companies that are not in a position to repay loans or interest for the loans taken.

While the reasons for such a large number of "stressed assets" is largely attributed to "low demand" and a lack of long term "power purchase agreements", this stands as a warning for continued investments in "coal power plants", given that 'water availability", would soon also be a major driver impacting electricity generation in India.

As we have seen in the previous sections, coal power plants are water intensive and coupled with the fact that India is a drought prone country, water availability in the future is a major question, particularly in a business as usual scenario.

India is already seeing declining per-capita water availability with many river basins that are either water stressed or likely to be water scarce. Further, given our growing population and coupled with the fact that Indian economy is largely agrarian in nature, there is likely to be increasing and competing water demand, with the demand-supply gap widening. This situation is likely to worsen, if more coal power plants are added, because, as it is, there are estimates, that the current consumption of water by coal power plants is 22 Billion Cubic Meter, which as reported elsewhere in the report, is over of half of India's estimated domestic water requirement.

A report released by WRI recently states that "more than 70 percent of India's existing thermal utilities are likely to experience an increased level of water competition from agricultural, urban, and other industrial demands by 2030.

In view of the above, some of the key issues that needs to be looked into are:

a) Accord permission for new coal power plants based on a detailed assessment of water availability amongst others.

b) Priority needs to be given to power plants that are less water intensive. For instance, wind generation is not a water intensive electricity generation source and neither is solar.

c) Permissions for setting up electricity generation capacity addition needs to be in line with projected demand.

d) Government needs to enforce stringent water consumption norms for current and pipeline power projects. The current rule stipulates that the water consumption needs to be restricted to $3m^3$/MWh. There is a huge potential to reduce this further, with putting in mandatory water recycling and reuse regulations.

e) Introduce rational water tariffs for all industrial supply.

f) Regular water audits should be mandatory for coal power plants.

[17] Ministry of Power, March 2018, Stressed/Non-performing Assets in Electricity Sector, Thirty-Seven Report, Standing Committee on Energy (2017-18), Sixteenth Lok Sabha, Lok Sabha Secretariat, New Delhi. Available online at http://164.100.47.193/lsscommittee/Energy/16_Energy_37.pdf

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Annexure

Coal Power Plants operating at below 20 percent				
Name of Power Plant	State	Implementing Agency	Capacity (MW)	Plant Load Factor (%)
Barauni Thermal Power Station (BTPS) Unit 6	Bihar, Begusarai	Bihar State Electricity Board	105	0
Barauni Thermal Power Station (BTPS) Unit 7	Bihar, Begusarai	Bihar State Electricity Board	105	0
Pathadi Thermal Power Plant Phase I Unit 2	Chhattisgarh, Korba	Lanco Amarkantak Power Pvt Ltd.	300	0
Katghora Thermal Power Plant Unit 1	Chhattisgarh, Korba	Vandana Energy & Steel Pvt. Ltd.	35	0
SVPL TPP Unit 1	Chhattisgarh, Korba	SVPPL	63	0
Baradarha Thermal Power Station Unit 1	Chhattisgarh, Jangjir - Champa	DBPCL	600	0
Gandhi Nagar Thermal Power Station Unit 1	Gujarat, Gandhi Nagar	Gujarat State Energy Corp. Ltd.	120	0
Patratu Thermal Power Station Unit 1	Jharkhand, Ramgarh	Jharkhand State Electricity Board	40	0
Patratu Thermal Power Station Unit 2	Jharkhand, Ramgarh	Jharkhand State Electricity Board	40	0
Patratu Thermal Power Station Unit 3	Jharkhand, Ramgarh	Jharkhand State Electricity Board	40	0
Patratu Thermal Power Station Unit 4	Jharkhand, Ramgarh	Jharkhand State Electricity Board	40	0
Patratu Thermal Power Station Unit 5	Jharkhand, Ramgarh	Jharkhand State Electricity Board	90	0
Patratu Thermal Power Station Unit 7	Jharkhand, Ramgarh	Jharkhand State Electricity Board	105	0
Patratu Thermal Power Station Unit 8	Jharkhand, Ramgarh	Jharkhand State Electricity Board	105	0
Patratu Thermal Power Station Unit 9	Jharkhand, Ramgarh	Jharkhand State Electricity Board	110	0
Satpura Thermal Power Station Stage I Unit 1	Madhya Pradesh, Betul	M.P. Power Generating Corp. Ltd.	62.5	0
Koradi Thermal Power Station Unit 1	Maharashtra, Nagpur	Maharashtra State Power Generation Co. Ltd.	105	0
Koradi Thermal Power Station Unit 2	Maharashtra, Nagpur	Maharashtra State Power Generation Co. Ltd.	105	0
Koradi Thermal Power Station Unit 3	Maharashtra, Nagpur	Maharashtra State Power Generation Co. Ltd.	105	0
Koradi Thermal Power Station Unit 4	Maharashtra, Nagpur	Maharashtra State Power Generation Co. Ltd.	105	0
Bhusawal Coal based TPS Unit 1	Maharashtra, Jalgaun	Maharashtra State Power Generation Co. Ltd.	55	0
Parli Thermal Power Station Unit 3	Maharashtra, Beed	Maharashtra State Power Generation Co. Ltd.	210	0
Wardha Warora TPP Phase I Unit 2	Maharashtra, Chandrapur	Wardha Power Co. Ltd.	135	0
Mihan Power Station Unit 1	Maharashtra, Nagpur	Abhijeet MADC Nagpur Energy Pvt Ltd.	61.5	0
Mihan Power Station Unit 2	Maharashtra, Nagpur	Abhijeet MADC Nagpur Energy Pvt Ltd.	61.5	0
Mihan Power Station Unit 3	Maharashtra, Nagpur	Abhijeet MADC Nagpur Energy Pvt Ltd.	61.5	0
Mihan Power Station Unit 4	Maharashtra, Nagpur	Abhijeet MADC Nagpur Energy Pvt Ltd.	61.5	0
Bela Thermal Power Station Unit 1	Maharashtra, Nagpur	Ideal Energy Power Ltd.	270	0
Gupta Energy Thermal Plant Phase I Unit 1	Maharashtra, Chandrapur	Gupta Energy Pvt Ltd.	60	0
Gupta Energy Thermal Plant Phase I Unit 2	Maharashtra, Chandrapur	Gupta Energy Pvt Ltd.	60	0
Nasik RattanIndia Thermal Power station (NASIK (P)) Unit 4/ Indiabulls Nasik Thermal Power Station Unit 4	Maharashtra, Nashik	Rattanindia/ Indiabulls Power Ltd.	270	0
Nasik RattanIndia Thermal Power station (NASIK (P)) Unit 5/ Indiabulls Nasik Thermal Power Station Unit 5	Maharashtra, Nashik	Rattanindia/ Indiabulls Power Ltd.	270	0
Talwandi Sabo Thermal Power Plant Unit 1	Punjab, Mansa	Talwandi Sabo Power Ltd.	660	0
Neyveli Thermal Power Station (Expansion) Stage II (NEYVELI TPS II (EXT)) Unit 1	Tamil Nadu, Cuddalore	Neyveli Lignite Corp. Ltd.	250	0
Harduaganj TPS Phase I Unit 7	Uttar Pradesh, Aligarh	Uttar Pradesh Rajya Vidyut Utpadan Nigam Ltd.	110	0
Parichha Power Station Stage I Unit 2	Uttar Pradesh, Jhansi	Uttar Pradesh Rajya Vidyut Utpadan Nigam Ltd.	110	0
Obra Thermal Power Station A Unit 7	Uttar Pradesh, Sonebhadra	Uttar Pradesh Rajya Vidyut Utpadan Nigam Ltd.	94	0

Obra Thermal Power Station A Unit 8	Uttar Pradesh, Sonebhadra	Uttar Pradesh Rajya Vidyut Utpadan Nigam Ltd.	94	0
Obra Thermal Power Station B Unit 10	Uttar Pradesh, Sonebhadra	Uttar Pradesh Rajya Vidyut Utpadan Nigam Ltd.	200	0
Obra Thermal Power Station B Unit 11	Uttar Pradesh, Sonebhadra	Uttar Pradesh Rajya Vidyut Utpadan Nigam Ltd.	200	0
Santaldih Thermal Power Station Unit 1	West Bengal, Purulia	West Bengal Power Development Corp. Ltd.	120	0
Santaldih Thermal Power Station Unit 2	West Bengal, Purulia	West Bengal Power Development Corp. Ltd.	120	0
Santaldih Thermal Power Station Unit 3	West Bengal, Purulia	West Bengal Power Development Corp. Ltd.	120	0
Santaldih Thermal Power Station Unit 4	West Bengal, Purulia	West Bengal Power Development Corp. Ltd.	120	0
Bandel Thermal Power Station Unit 5	West Bengal, Hooghly	West Bengal Power Development Corp. Ltd.	210	0
Durgapur Projects Ltd. Thermal Power Plant (D.P.L. TPS) Unit 3	West Bengal, Bardhman	Durgapur Projects Ltd.	70	0
Durgapur Projects Ltd. Thermal Power Plant (D.P.L. TPS) Unit 4	West Bengal, Bardhman	Durgapur Projects Ltd.	75	0
Durgapur Projects Ltd. Thermal Power Plant (D.P.L. TPS) Unit 5	West Bengal, Bardhman	Durgapur Projects Ltd.	75	0
Durgapur Projects Ltd. Thermal Power Plant (D.P.L. TPS) Unit 6	West Bengal, Bardhman	Durgapur Projects Ltd.	110	0
New Cossipore Generating Station Unit 1	West Bengal, Kolkata	Calcutta Electric Supply Corp. Ltd.	30	0.6
Gandhi Nagar Thermal Power Station Unit 2	Gujarat, Gandhi Nagar	Gujarat State Energy Corp. Ltd.	120	0.8
Koradi Thermal Power Station Unit 5	Maharashtra, Nagpur	Maharashtra State Power Generation Co. Ltd.	200	0.8
Ennore Thermal Power Station Unit 5	Tamil Nadu, Thiruvallur	Tamil Nadu Generation & Distribution Corp. Ltd.	110	1.7
Ennore Thermal Power Station Unit 2	Tamil Nadu, Thiruvallur	Tamil Nadu Generation & Distribution Corp. Ltd.	60	3.1
Wardha Warora TPP Phase I Unit 1	Maharashtra, Chandrapur	Wardha Power Co. Ltd.	135	4.7
New Cossipore Generating Station Unit 3	West Bengal, Kolkata	Calcutta Electric Supply Corp. Ltd.	50	4.7
Derang Thermal Power Plant Unit 1	Odisha, Angul	Jindal India Thermal Power Ltd. (JITPL)	600	4.9
New Cossipore Generating Station Unit 2	West Bengal, Kolkata	Calcutta Electric Supply Corp. Ltd.	30	5
Mahan TPP Unit 1	Madhya Pradesh, Singrauli	ESSARPMPL	600	8.6
Koderma TPP Unit 1	Jharkhand, Koderma	Damodar Valley Corporation (DVC)	500	9.7
Ukai Thermal Power Station/ UKAI Unit 2	Gujarat, Surat	Gujarat State Energy Corp. Ltd.	120	10
Panipat Thermal Power Station Stage II Unit 3	Haryana, Panipat	Haryana Power Generation Corp. Ltd. (HPGCL)	110	10.1
Giral Lignite Power Station Unit 1	Rajasthan, Barmer	Rajasthan Rajya Vidyut Utpadan Nigam Ltd.	125	10.5
Ukai Thermal Power Station/ UKAI Unit 1	Gujarat, Surat	Gujarat State Energy Corp. Ltd.	120	10.7
Dhariwal TPP Unit 1	Maharashtra, Chandrapur	Dhariwal Infrastructure(P) Ltd.	300	11.5
Panipat Thermal Power Station Stage I Unit 2	Haryana, Panipat	Haryana Power Generation Corp. Ltd. (HPGCL)	110	12.1
Salora Thermal Power Plant Unit 1	Chhattisgarh, Korba	Vandana Vidyut Ltd.	135	12.4
Panipat Thermal Power Station Stage I Unit 1	Haryana, Panipat	Haryana Power Generation Corp. Ltd. (HPGCL)	110	13.5
Panipat Thermal Power Station Stage II Unit 4	Haryana, Panipat	Haryana Power Generation Corp. Ltd. (HPGCL)	110	13.9
Ennore Thermal Power Station Unit 3	Tamil Nadu, Thiruvallur	Tamil Nadu Generation & Distribution Corp. Ltd.	110	14.8
Bhusawal Coal based TPS Unit 2	Maharashtra, Jalgaun	Maharashtra State Power Generation Co. Ltd.	210	15
Guru Nanak Dev Thermal Power Station Unit 4	Punjab, Bathinda	Punjab State Power Corp. Ltd.	110	15.4
New Cossipore Generating Station Unit 4	West Bengal, Kolkata	Calcutta Electric Supply Corp. Ltd.	50	15.5
Mejia TPS Unit 4	West Bengal, Bankura	Damodar Valley Corporation (DVC)	210	16.3
Bokaro B Thermal Power Station Unit 3	Jharkhand, Bokaro	Damodar Valley Corporation (DVC)	210	17.4
Trombay Thermal Power Station Unit 6	Maharashtra, Mumbai	Tata Power Co. Ltd.	500	19.1
Chandrapura (DVC) Thermal Power Station Unit 2	Jharkhand, Bokaro	Damodar Valley Corporation (DVC)	130	19.7

Coal Power Plants operating between 20-50 percent

Name of Power Plant	State	Implementing Agency	Capacity (MW)	Plant Load Factor (%)
Tamnar TPP/ Jindal Power Ltd. STPPS II Unit 1	Chhattisgarh, Raigarh	Jindal Power Ltd. (JPL)	600	22.1
Giral Lignite Power Station Unit 2	Rajasthan, Barmer	Rajasthan Rajya Vidyut Utpadan Nigam Ltd.	125	22.2
Tamnar TPP/ Jindal Power Ltd. STPPS II Unit 2	Chhattisgarh, Raigarh	Jindal Power Ltd. (JPL)	600	23.7
Chandrapur (Maharashtra) Super Thermal Power Station Unit 1	Maharashtra, Chandrapur	Maharashtra State Power Generation Co. Ltd.	210	23.8
Harduaganj TPS Phase I Unit 5	Uttar Pradesh, Aligarh	Uttar Pradesh Rajya Vidyut Utpadan Nigam Ltd.	60	23.8
Badarpur Thermal Power Station Unit 2	Delhi, South Delhi	NTPC Ltd.	95	24.6
Mauda TPS Phase I Unit 2	Maharashtra, Nagpur	NTPC Ltd.	500	24.9
Durgapur Steel TPS Unit 2	West Bengal, Bardhman	Damodar Valley Corporation (DVC)	500	25.3
Ennore Thermal Power Station Unit 4	Tamil Nadu, Thiruvallur	Tamil Nadu Generation & Distribution Corp. Ltd.	110	25.6
Kalisindh Thermal Power Station Unit 1	Rajasthan, Jhalawar	Rajasthan Rajya Vidyut Utpadan Nigam Ltd.	600	25.8
Durgapur Projects Ltd Thermal Power Plant (D.P.L. TPS) Unit 8	West Bengal, Bardhman	Durgapur Projects Ltd.	250	26.1
Rajghat Thermal Power Station/ Rajghat Power House Unit 2	Delhi, Central Delhi	Indraprastha Power Generation Co. Ltd.	67.5	26.5
Muzaffarpur Thermal Power Station (KBUNL Stage I) Unit 2	Bihar, Muzaffarpur	NTPC Ltd./Kanti Bijlee Utpadan(KBUNL)	110	26.9
Badarpur Thermal Power Station Unit 3	Delhi, South Delhi	NTPC Ltd.	95	27.9
Mauda TPS Phase I Unit 1	Maharashtra, Nagpur	NTPC Ltd.	500	27.9
Panipat Thermal Power Station Stage III Unit 5	Haryana, Panipat	Haryana Power Generation Corp. Ltd.(HPGCL)	210	28.3
Kutchh Lignite Thermal Power Station/ Kutch Lig. TPS Stage I Unit 3	Gujarat, Kutch	Gujarat State Energy Corp. Ltd.	75	28.4
Shri Singhaji Thermal Power Project Stage I or Malwa TPP Unit 1	Madhya Pradesh, Khandwa	M.P. Power Generating Corp. Ltd.	600	28.8
Amaravati TPS Unit 2	Maharashtra, Amravati	Rattanindia	270	29.6
Parli Thermal Power Station Unit 4	Maharashtra, Beed	Maharashtra State Power Generation Co. Ltd.	210	29.8
Patratu Thermal Power Station Unit 6	Jharkhand, Ramgarh	Jharkhand State Electricity Board	90	30.1
Bokaro B Thermal Power Station Unit 1	Jharkhand, Bokaro	Damodar Valley Corporation (DVC)	210	30.9
Sterlite (Jharsuguda)Thermal Power Plant Unit 1	Odisha, Jharsuguda	Sterlite Energy Ltd.	600	31.4
Sterlite (Jharsuguda)Thermal Power Plant Unit 2	Odisha, Jharsuguda	Sterlite Energy Ltd.	600	31.8
Guru Nanak Dev Thermal Power Station Unit 2	Punjab, Bathinda	Punjab State Power Corp. Ltd.	110	32.4
Trombay Thermal Power Station Unit 8	Maharashtra, Mumbai	Tata Power Co. Ltd.	250	32.7
Badarpur Thermal Power Station Unit 1	Delhi, South Delhi	NTPC Ltd.	95	33.8
North Chennai Thermal Power Station Stage II Unit 4	Tamil Nadu, Thiruvallur	Tamil Nadu Generation & Distribution Corp. Ltd.	600	34.1
Talwandi Sabo Thermal Power Plant Unit 2	Punjab, Mansa	Talwandi Sabo Power Ltd.	660	34.8
Mejia TPS Unit 3	West Bengal, Bankura	Damodar Valley Corporation (DVC)	210	35.1
Ramagundem Thermal Power Station B (Ramagundem - B) Unit 1	Telangana, Mancherial	Telangana State Power Generation Corp. Ltd (TSGENCO)	62.5	35.3
Koderma TPP Unit 2	Jharkhand, Koderma	Damodar Valley Corporation (DVC)	500	35.7
Panipat Thermal Power Station Stage IV Unit 6	Haryana, Panipat	Haryana Power Generation Corp. Ltd. (HPGCL)	210	36.4
Vallur Thermal Power Plant Unit 3	Tamil Nadu, Chennai	NTPC Tamil Nadu Energy Co. Ltd.	500	36.5
Wardha Warora TPP Phase II Unit 4	Maharashtra. Chandrapur	Wardha Power Co. Ltd.	135	36.6
Ennore Thermal Power Station Unit 1	Tamil Nadu, Thiruvallur	Tamil Nadu Generation & Distribution Corp. Ltd.	60	37.9
Bhusawal Coal based TPS Unit 3	Maharashtra, Jalgaun	Maharashtra State Power Generation Co. Ltd.	210	38.8
Parichha Power Station Stage I Unit 1	Uttar Pradesh, Jhansi	Uttar Pradesh Rajya Vidyut Utpadan Nigam Ltd.	110	39.2

Kamalanga TPS Unit 3	Odisha, Dhenkanal	GMR Energy Ltd.	350	40.1
Ropar TPS or Guru Gobind Singh STPP Unit 6	Punjab, Rupnagar	Punjab State Power Corp. Ltd.	210	40.1
Durgapur Projects Ltd Thermal Power Plant (D.P.L. TPS) Unit 7	West Bengal, Bardhman	Durgapur Projects Ltd.	300	40.2
Bokaro B Thermal Power Station Unit 2	Jharkhand, Bokaro	Damodar Valley Corporation(DVC)	210	40.5
Durgapur Thermal Power Station (DVC) Unit 4	West Bengal, Bardhman	Damodar Valley Corporation (DVC)	210	40.8
Rajiv Gandhi Thermal Power Station/ RGTPP Unit 2	Haryana, Hisar	Haryana Power Generation Corp. Ltd. (HPGCL)	600	41.6
Mahadev Prasad Super Thermal Power Station or Jamshedpur Kandra power station/ AHUNIK Power & Nat. Res. Unit 2	Jharkhand, Sareikela	ADHUNIK	270	41.7
Guru Nanak Dev Thermal Power Station Unit 1	Punjab, Bathinda	Punjab State Power Corp. Ltd.	110	41.7
Obra Thermal Power Station B Unit 12	Uttar Pradesh, Sonebhadra	Uttar Pradesh Rajya Vidyut Utpadan Nigam Ltd.	200	43.5
Sikka Thermal Power Station Stage I Unit 2	Gujarat, Jamnagar	Gujarat State Energy Corp. Ltd.	120	44
Satpura Thermal Power Station Stage IV Unit 10	Madhya Pradesh, Betul	M.P. Power Generating Corp. Ltd.	250	44
Wanakbori Thermal Power Station Unit 5	Gujarat, Kheda	Gujarat State Energy Corp. Ltd.	210	44.2
Indira Gandhi Super Thermal Power Project Unit 3	Haryana, Jhajjar	Aravali Power Co. Pvt Ltd. (APCPL)	500	44.2
Obra Thermal Power Station B Unit 13	Uttar Pradesh, Sonebhadra	Uttar Pradesh Rajya Vidyut Utpadan Nigam Ltd.	200	44.2
Sanjay Gandhi Thermal Power Station/ SGTPS Phase I Unit 1	Madhya Pradesh, Shahdol	M.P. Power Generating Corp. Ltd.	210	44.9
Raichur Thermal Power Station Unit 8	Karnataka, Raichur	Karnataka Power Corp. Ltd.	250	45.1
Rajghat Thermal Power Station/ Rajghat Power House Unit 1	Delhi, Central Delhi	Indraprastha Power Generation Co. Ltd.	67.5	45.2
Sterlite (Jharsuguda)Thermal Power Plant Unit 3	Odisha, Jharsuguda	Sterlite Energy Ltd.	600	45.4
Gandhi Nagar Thermal Power Station Unit 3	Gujarat, Gandhi Nagar	Gujarat State Energy Corp. Ltd.	210	45.7
Sikka Thermal Power Station Stage I Unit 1	Gujarat, Jamnagar	Gujarat State Energy Corp. Ltd.	120	45.7
Bandel Thermal Power Station Unit 4	West Bengal, Hooghly	West Bengal Power Development Corp. Ltd.	60	45.8
Sanjay Gandhi Thermal Power Station/ SGTPS Phase II Unit 3	Madhya Pradesh, Shahdol	M.P. Power Generating Corp. Ltd.	210	45.9
Mejia TPS Unit 2	West Bengal, Bankura	Damodar Valley Corporation (DVC)	210	46.9
Wanakbori Thermal Power Station Unit 4	Gujarat, Kheda	Gujarat State Energy Corp. Ltd.	210	47.3
Satpura Thermal Power Station Stage II Unit 6	Madhya Pradesh, Betul	M.P. Power Generating Corp. Ltd.	200	47.3
Mejia TPS Unit 1	West Bengal, Bankura	Damodar Valley Corporation (DVC)	210	47.3
Sterlite (Jharsuguda)Thermal Power Plant Unit 4	Odisha, Jharsuguda	Sterlite Energy Ltd.	600	48
Indira Gandhi Super Thermal Power Project Unit 2	Haryana, Jhajjar	Aravali Power Co. Pvt Ltd. (APCPL)	500	48.3
Durgapur Thermal Power Station (DVC) Unit 3	West Bengal, Bardhman	Damodar Valley Corporation (DVC)	130	48.4
Rajpura TPP Unit 1	Punjab, Patiala	NPL	700	48.6
Amarkantak TPS Stage I Unit 1	Madhya Pradesh, Anuppur	M.P. Power Generating Corp. Ltd.	120	49.3
Tuticorin Thermal power plant (TPP) (Tuticorin (P)) Unit 1	Tamil Nadu,Thoothukudi	IBPIL	150	49.3
Barh STPP II Unit 4	Bihar, Patna	NTPC Ltd.	660	49.4
Satpura Thermal Power Station Stage III Unit 9	Madhya Pradesh, Betul	M.P. Power Generating Corp. Ltd.	210	49.4
Ropar TPS or Guru Gobind Singh STPP Unit 1	Punjab, Rupnagar	Punjab State Power Corp. Ltd.	210	49.9
Ropar TPS or Guru Gobind Singh STPP Unit 2	Punjab, Rupnagar	Punjab State Power Corp. Ltd.	210	49.9

Vasudha Foundation is a Not-for-Profit Trust working in the Clean Energy and Climate Policy Space since April 2010. The Organisation believes in the conservation of "Vasudha", which in sanskrit means the "Earth".

The mission of Vasudha Foundation is to promote environment-friendly, socially just and sustainable models of energy by focusing on renewable energy and energy efficient technologies and lifestyle solutions. The Organisation aims to fulfil its mission primarily through promoting low carbon development and deployment of renewable energy in India. We believe that all Indians must achieve a decent standard of living that will include access to basic building blocks of a decent lifestyle including energy access, without necessarily following a path of development that depletes the resources of the earth.

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The **Heinrich Böll Stiftung/ Heinrich Boell Foundation** is a German foundation and part of the Green political movement that has developed worldwide as a response to the traditional politics of socialism, liberalism, and conservatism. We are a green think-tank and an international policy network, our main tenets are ecology and sustainability, democracy and human rights, self-determination and justice. We place particular emphasis on gender democracy, meaning social emancipation and equal rights for women and men. We are also committed to equal rights for cultural and ethnic minorities. Finally, we promote non-violence and proactive peace policies. To achieve our goals, we seek strategic partnerships with others who share our values.

Our namesake, Heinrich Böll, personifies the values we stand for: protection of freedom, civic courage, tolerance, open debate, and the valuation of art and culture as independent spheres of thought and action.

Our India Liaison Office was established in 2002 in New Delhi. Working with governmental and non-governmental local project partners we support India's democratic governance through informed national and international dialogue processes with a view to enhance the diversity of green thinking.

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