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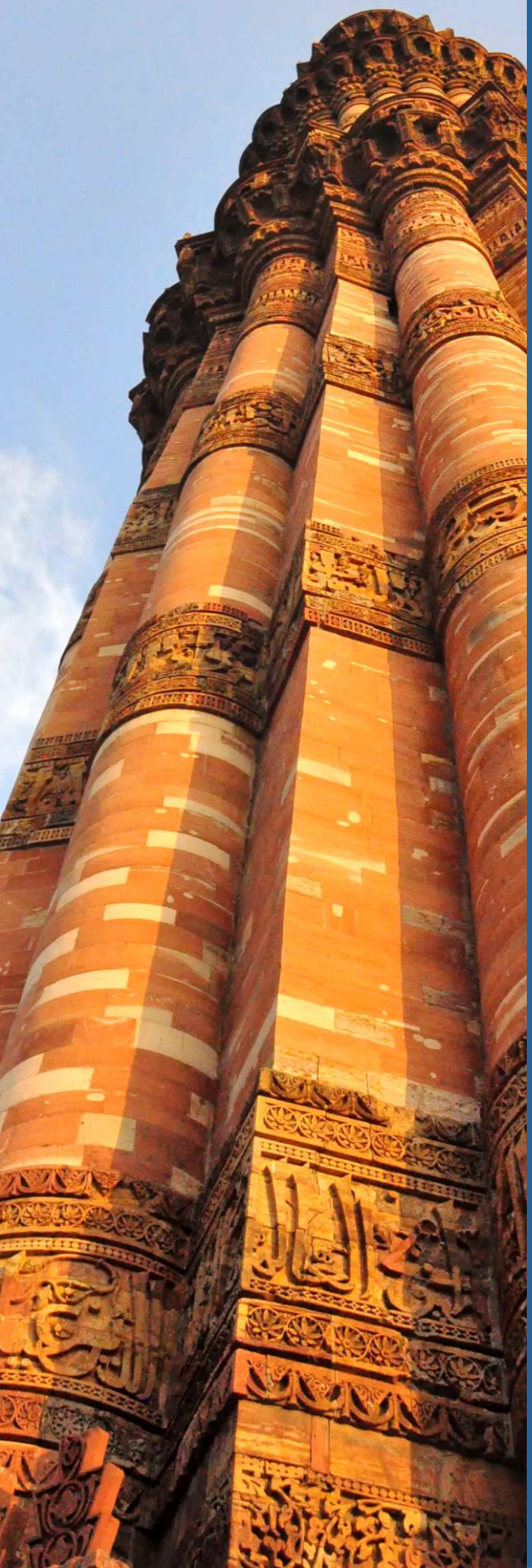

Challenges and Recommendations for Meeting the Upcoming 2017 Standards for Air Pollution from Thermal Power Plants in India

BY
RAHUL TONGIA
DEBORAH SELIGSOHN

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No. 6, Second Floor, Dr. Jose P Rizal Marg
Chanakyapuri, New Delhi - 110021
www.brookings.in

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Challenges and Recommendations for Meeting the Upcoming 2017 Standards for Air Pollution from Thermal Power Plants in India[1]

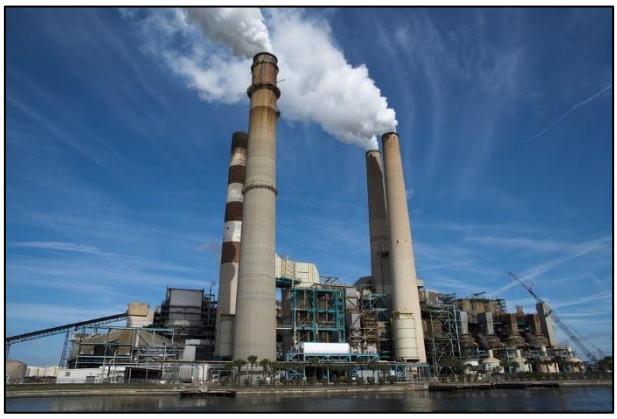
Rahul Tongia

Deborah Seligsohn[2]

[1] This piece draws from a discussion on Lessons from China for India's new power plant pollution norms, between Brookings India Fellow Rahul Tongia and UC San Diego scholar and environmental policy expert Deborah Seligsohn, available online,[1] combining snippets from that conversation with additional insights and analysis.

[2] Rahul Tongia is a Fellow for Energy and Sustainability at Brookings India; and Deborah Seligsohn is an Environmental Policy Scholar at UC San Diego.

Key Insights:



- The upcoming environmental norms for thermal power plants are a welcome step in reducing emissions as well as in line with global standards. However, unlike in China, older plants, depending on their age, are grandfathered into allowing their existing emissions norms or have weaker requirements than new plants.

- The technologies for complying are mostly off-the-shelf, and thus these appear technologically feasible. There is some uncertainty though about the level of modification needed for NOx reduction for Indian coal which is high in ash content, as well as Indian industry's capacity to meet the volumes of installation required in a short period of time.

- The timeframes for compliance appear overly aggressive and somewhat unfeasible. Technical assessment and simple learning will take time, especially given limited Indian experience, but there is also a need to schedule plant shutdowns and for the tariff petitions to pass through the costs for such technologies. These could be reduced via standardised costings for pass-through to consumers (Rs./kWh)

- The estimated costs for compliance are measurable but likely affordable (up to few tens of paise/kWh), translating to generation power cost increases on the order of 5-7 per cent for plants with all equipment installed; plants without state-of-the art upgrades would result in a lower cost increase. Translating these to end-consumer average tariff increases would diminish the consumer impact substantially since not all retail electricity costs are generation (typically 70+ per cent is generation in India), and not all generation is coal, and not all coal plants need all such equipment. The economics for older plants being retrofit are more complex, with sometimes simpler and less expensive solutions sufficing, but a much shorter remaining lifespan during which to recoup the expenses.

- Compliance with the norms is contingent on monitoring and enforcement, which starts with proper (and calibrated) continuous emission monitoring systems (CEMS). This extends to proper manpower to physically inspect the CEMS in statutory pollution control boards, where India lags behind China by 1-2 orders of magnitude. In addition to CEMS for power plants, there is an urgent need to increase air quality monitoring sites, especially outside the larger cities.

- One needs a feasible roadmap for installation of required equipment, in addition to improvements in norms that incentivise if not mandate dispatching cleaner coal first. This requires a multi-stakeholder discussion as soon as possible, bringing together not just power plants and the government but also state utilities and grid operators.

Upcoming Thermal Power Plant emissions and environmental Norms

In the first half of 2015, the Ministry of Environment, Forest and Climate Change (MoEFCC) issued drafts of stricter norms for emissions and water consumption for coal-based thermal power sector. According to the new standards, shown below, thermal power plants are expected to cut emissions and usage of water measurably. It is not clear what the penalties for failure might be, especially in the short-run (while plants are scrambling to improve their technology).

Table 1: Upcoming environmental norms for Thermal Power Plants (TPPs) in India.

	Existing (prior) Standards	TPPs installed till Dec 31, 2003	TPPs installed between Jan 1, 2004 and Dec 31, 2016	TPPs to be installed from January 1, 2017
Sulphur Dioxide	No standard	600 mg/Nm^3 (for units < 500 MW) 200 mg/Nm^3 (for units >= 500 MW)	600 mg/Nm^3 (for units<500 MW) 200 mg/Nm^3 (for units>500 MW)	100 mg/Nm3
Oxides of Nitrogen (NOx)	No standard	600 mg/Nm^3	300 mg/Nm^3	100 mg/Nm^3
Mercury	No standard	0.03 mg/Nm^3 (for units >= 500 MW)	0.03 mg/Nm^3	0.03 mg/Nm^3
Particulate Matter (PM)	150-350 mg/NM^3	100 mg/Nm^3	50 mg/Nm^3	30 mg/Nm^3
Water Consumption	not available	3.5 m^3 /MWh	3.5 m^3 /MWh	2.5 m^3 /MWh

Source: MoEFCC, as compiled by ICRA Ltd. and CSE.

While the norms have been welcomed by most environmentalists, gaps remain in their viability and implementation.

The China example: Aggressive norms leading to improvements in air quality

China, with similar air pollution levels, may be a good starting point to compare whether and how the country has tackled this issue.

China has historically been considered to have severe air pollution, much of it from power plants. One major caveat though is that China's air quality is improving thanks to ten concentrated years of cleaning up, while India's still on a worsening trend. Also, China has mostly met its electricity access requirements, and growth of power (demand) is tapering. In India, meanwhile, power demand will still grow measurably, much of it with coal-based power.

China also has stringent power plant emission norms, and the norms currently being implemented surpass those of the U.S. and Europe. Importantly, China mandates retrofitting of older plants as well (since 2011 in practice there has been no grandfathering of selected plants). Part of China's clean-up involved shutting down older, smaller, dirtier plants. Age of plants is not necessarily a

barrier: the average U.S. coal plant is over 40 years old and many were retrofitted to meet environmental norms.

Meeting the norms: Technologically doable, but with effort

India's planned power plant emissions norms, which were notified in late 2015,[3] for the first time added sulfur dioxide, nitrogen oxides (NOx), and mercury, going beyond older particulate matter (PM) norms. The norms vary by plant vintage—older plants face improved but still relatively looser norms, while newer plants will need to become comparable to global best practices (i.e. U.S. and European standards, the Chinese are still tougher). Power plants, even though they are just one of several sources of air pollution (crop burning, vehicles, construction, etc. being others), are a measurable source with only a few hundred locations to act upon, and thus a low-hanging fruit.

In principle, the norms are technologically achievable, for the most part, as they use "off-the-shelf" technology that is decades old, and should not be patent protected. However, the time frame for implementation—announced in December 2015, to go into force in December 2017—appears too aggressive and perhaps even unrealistic. With (then) about double India's coal generation capacity, it took China three years to install some level of retrofits for some three-fourth of its thermal power plants.

The current public focus in India appears to be towards particulate matter (specifically PM 2.5). Some advocate focusing on particulate emissions first, even as ascribed to officials in the government.[4] This would not address the problems that the norms aim to correct. Both sulfur dioxide and NOx, while emitted as gases, convert to particulate matter (PM) after atmospheric reactions. Moreover, particulate control equipment (electrostatic precipitators) is already installed at Indian power plants, though there are some concerns on operations, efficacy, and risks of plants bypassing or avoiding using such equipment, in addition to the need to add equipment to some plants to meet the newer standards. To actually make significant progress India needs the standards contained in the 2015 notice, which address these gaseous causes of PM 2.5.

Small tweaks to technologies may be required for Indian conditions – there just isn't any data since these aren't yet installed in a meaningful level (a few installations of sulfur control –Flue Gas Desulfurization [FGD], are underway or recently done). This also means equipment pricing data are limited. The largest unknown may be NOx control for high-ash Indian, since catalytic reduction (SCR) must be done while the gases are hot, i.e., before removal of ash.

India used to claim that its coal was low-sulfur, and hence FGD technology wasn't required. *To meet the norms, FGD will be required*. Even so-termed low-sulfur coal becomes negated if the ash content is high (and hence calorific value is low) – more coal is required per kilowatt-hour electricity. This is where good data are required, and monitoring (continuous environmental monitoring systems, or CEMS) are a work-in-progress.

India may need to rethink calibration of its sensors, especially with tighter emission norms. The U.S. norm is for daily calibration, which de-facto requires automated systems, which are more

[3] http://pib.nic.in/newsite/PrintRelease.aspx?relid=133726
[4] https://www.bloomberg.com/news/articles/2016-11-02/india-wavers-on-emissions-goal-as-power-plants-balk-at-price-tag

expensive. The Chinese situation is more complex with both automatic CEMS calibrated daily and manual systems that are calibrated fortnightly for gases and quarterly for particulates. However, some 90 per cent of Chinese CEMS are the automatic type that are calibrated daily, and this would appear the best choice for accuracy. India reportedly calibrates every six months.[5]

Sanctity of the CEMs data is another concern. China has chosen to "black box" the raw data to prevent operator manipulation and to have regular physical inspections to prevent human manipulation at the calibration level. Anecdotally, this is an issue in India with some plants complying, per sensors, but alternative measurements indicating they do not.

Physically implementing environmental control norms includes the following steps:

- Design of solutions
- Tariff petitions
- Tendering and procurement
- Shut-down for installation (60-90 days each)

It is extremely unlikely this can be done by December 2017. While Central public sector undertaking NTPC Ltd. has been proactive in such efforts, state generators have, on average, been lagging. One of the challenges the Central Electricity Authority of India has highlighted is lack of space for FGD equipment, especially for 74+ GW of coal plants predominantly under 500 MW in size. It is unclear if this is a reality, an excuse/bargaining point, or something that can be overcome but with additional cost. Recent newspaper reports indicate[6] that the Ministry of Power is coordinating with the MoEFCC for extending the deadline.

Improved monitoring is key to compliance

India must accelerate CEMS deployment. In fact, real-time data can be made public, not just be sent to Pollution Control Board (PCB) officials. China has dozens of plants with real-time data made public already and has required that all plants put their data on line.

The data must be made available not just to the power plant operator, but to multiple levels of pollution control, state-wise, locally, and nationally. In addition, air quality needs to be monitored not just in urban areas. Given that power plants are nowadays mostly outside urban areas, monitoring such areas is important for understanding causality for urban pollution, especially when we consider non-particulate sources (including those that eventually become particulates). To date, most air quality index (AQI) sensors are in urban areas, but insufficient for developing full source data and understanding pollution patterns.

Better monitoring and models will help understand PM 2.5 and PM 10 pollution (particulate pollution of 2.5 microns and 10 microns size, respectively. The smaller the pollutant, the more dangerous to human health given it can be more easily absorbed (and it's harder to filter). PM 2.5 is more combustion based, while the latter is also based on physical activity including construction. The latter needs different controls, e.g., mandating closed transport of materials, covered

[5] http://www.cseindia.org/userfiles/CEMS-ppt1.pdf
[6] http://timesofindia.indiatimes.com/home/environment/pollution/coal-fired-power-plants-get-more-time-for-upgrade/articleshow/57137553.cms

construction sites, etc. Fixing roads would reduce PM 10 and improve the efficiency of transportation, helping PM 2.5 levels as well.

Enforcement of norms is a key need. China has vastly more staff for their PCBs, or equivalent, with many more local staff. Reportedly, Delhi's PCB, with some 200 staff, has only 24 engineers or technical staff. Bihar has far fewer (total about 75 staff). Maharashtra is one of the best staffed, with a few thousand. While many Indian cities have environmental staff, they do not address air quality much, and instead focus on municipal solid waste. In contrast, the U.S. Environmental Protection Agency (EPA) has some 15,000 staff at a national level (possibly more adding in full-time contractors not on the direct payroll), and the sum total of state and local EPAs have a similar number. China has similar total staffing, with a different distribution — more at the provincial and local level, and 3,000-4,000 staff at the national level in the central ministry and connected institutes.

Economics (always) matters

We need to quickly understand the costs of compliance for power plants. While it may be competitive market, this market is nascent within India. Chinese costing data for FGD equipment came to some 15 paise/kWh (converted to Indian currency), plus some 1 per cent operating costs. NOx would add perhaps 50 per cent more. Doing a back of the envelope calculation, assuming even Rs 4 per kWh cost of coal-based power (pre-standards), the additional costs would be a little over 6 per cent of generation costs for plants with all equipment installed. These are similar to estimates by ICRA Ltd.[7] In our simplified calculations, we factor in energy consumption for the equipment (higher auxiliary consumption, perhaps 1.5 per cent) as well as higher operations and maintenance, plus a one-time hit due to two to three-months of minimum downtime for equipment installation.

A lot of cost numbers depend not only on applicable interest rates, and whether the solutions are imported, but also the load factors of the plants and their lifespans. Using gross average numbers, we can assume end-user [retail] power costs are 75 per cent based on power generation [procurement], and a little over 75 per cent of power is coal-based. Recognising that even older plants (which are cheaper than Rs 4/kWh) would face compliance costs, even assuming an upper bound cost of 8 per cent increase in coal generation costs would translate to an end-user cost increase of around 4 per cent overall. Spreading this out over two-three years means it should be affordable. In contrast, the human and gross domestic product costs of indoor plus outdoor air pollution (not just from coal power plants) is reported to be several times higher, e.g., by a World Bank and University of Washington study.[8]

There may be some tweaking and research and development[9] required for NOx controls with high-ash coals. If it turns out to be difficult or expensive, this would give a further impetus to washing coal, or perhaps increased imports of better quality coal.

[7] http://www.icra.in/Files/ticker/Power-T-1-November 2016.pdf
[8] http://documents.worldbank.org/curated/en/781521473177013155/pdf/108141-REVISED-Cost-of-PollutionWebCORRECTEDfile.pdf
[9] http://cseindia.org/userfiles/new-environmental-norms-report.pdf

Need for multi-stakeholder engagement

Two years is likely too short a period for implementation. While there was a stakeholder consultation period during 2015, some of the discussions would have been speculative or theoretical as India has nearly zero practical experience with actual deployments of relevant emissions control equipment. Instead of letting December 2017 arrive, and then we have a series of negotiations for delays (or phasing), the process for phasing in the norms should start immediately. While one could adopt a size-based criteria, ideally any progressive roadmap should factor in a combination of cost-effectiveness (bang for buck) and impact on human health. This isn't meant to be a waiver or even delay; just a realistic timeframe for implementation, with penalties or shut-down for non-compliance.

Beyond the technical limitations of equipment, which affects the design of equipment, the biggest bottleneck could be tariff petitions. Given such equipment is statutorily required, generators should have grounds for a tariff increase to meet the new norms. However, this currently would entail some hundreds of petitions across the country, many of them with respective State Electricity Regulatory Commissions (SERCs). In contrast, China has fixed the tariff increase for emissions norms, and actually monitors equipment use as part of payments. India should consider standardising the tariff increase for environmental compliance, perhaps (if required) with only a few variations based on specific parameters and criteria.

A major part of the phasing in of equipment must be the planning for the shut-downs of plants for installation. If one wants to delay installing NOx equipment, doing sulphur FGD first, that might save a little time in the short run, but necessitate a subsequent shutdown in the future. One small silver lining of (temporary) "surplus" coal power capacity (i.e., the falling plant load factors of coal plants) is that one can schedule downtime these with less disruption to the grid. One should have a dynamic, predictive process for scheduling shutdowns, factoring in seasonal demand, seasonal supply (esp. from renewables), monsoons, etc.

Older plants may be the dirtiest, but if they have less years of life ahead, they may be unviable based on lifespan. In contrast, older plants are less efficient (both because of operational issues as well as their technology, using sub-critical boilers instead of new super-critical or ultra-super-critical boilers), so if coal utilisation were a criteria for despatch, these would be called last. One solution is to create a new despatch mechanism that prioritises lower pollution (or broader sustainability) as a factor for merit order economic despatch of power plants. This would incentivise firms to install abatement equipment early and use it effectively. A second needed policy is a phase out policy for plants that are simply too old and too small for new equipment to ever pay off.

This is in addition to a suggestion by Dr. Sarath Guttikunda, of UrbanEmissions.info, to add short-term predictive air pollution quality criterion for despatch[10] of coal power plants. Whenever there is predicted severe local air pollution, and wind patterns are blowing plant emissions towards the city, one would choose to limit despatch of applicable coal plants, especially ones nearest to cities. This is futuristic, and requires better real-time coordination of despatch, and may even require power markets.

[10] http://www.brookings.in/managing-pollution-from-thermal-power-plants-and-brick-kilns-in-india/

One of the biggest challenges for this space (like many others) is *variance*. Many coal power plants have a different age, technology, size, location, ownership, load factor (utilisation factor), etc. Some parameters impact emissions, some impact the effects of the emissions, while others affect economic viability. We should have a minimum common standard for all, but we might want to consider market mechanisms to allow for rewarding (or punishing) variance further. A flipside of this is that we shouldn't treat pollution as simply a cost of doing business that can be compensated against (and hence becoming a source of revenue for governments!). Instead, India should focus on cost-effective and virtually universal norms for emissions, implemented and enforced as soon as possible.

Authors

Rahul Tongia

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

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

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

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

Deborah Seligsohn

Deborah Seligsohn is a scholar at the University of California, San Diego, and an expert on air pollution from power plants. From 2007 to 2012, she led and was Principal Advisor to the World Resources Institute's China Energy and Environmental Program. She was previously a US State Department officer on energy and environment issues, spending extensive time in South Asia and China. She served as the State Department's Counselor for science, energy and environment issues in Beijing before joining WRI.

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We look forward to active engagement with readers on the diagnoses and recommendations that these papers offer. Feedback can be sent directly to the authors.

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