Defeating the Airpocalypse: 13 solutions for clean air assessed

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With at least 550 million Indians, including 50 million children under 5, living in areas where air pollution levels exceed national standards, air pollution is a national health emergency. A new report by Louisiana State University researchers lays out 13 measures to reduce air pollution levels by 40% across India, avoiding 9 lakh premature deaths per year. In Delhi, wintertime PM2.5 levels would be reduced by 60% through these measures.

Summary

As India prepares a National Clean Air Plan, information on the sources and the most effective solutions to the high air pollution levels plaguing the country is sorely needed. To address this need, Louisiana State University researchers have carried out an atmospheric modeling study[1] that identifies ambient air pollution sources and analyses their contribution to pollution levels. The report assessed the air quality impacts of measures identified by Greenpeace India as having a high potential to address the emergency-level air pollution situation in India, targeting multiple sectors such as thermal power (operational, under-construction & new power plants), manufacturing industries, brickmaking, household solid fuels, transport, crop burning, municipal waste burning, construction and residential Diesel Generator sets use.

The measures with the largest potential for air quality improvements are reducing emissions from thermal power plants, instituting strong emissions standards for industries, reducing solid fuel use in households, shifting to zig-zag kilns in brickmaking, and introducing stronger vehicular emissions standards in an accelerated schedule. Each of these measures could prevent 0.8 to 1.8 lakh deaths per year from air pollution by implementing the suggested measures. Implementation of all 13 measures is necessary for achieve the 40% reduction in air pollution levels at the national scale.

The report evaluated policy measures addressing thermal power, manufacturing industries, brickmaking, household solid fuels, transport, crop burning, municipal waste burning, construction and DG sets.

Based on the results of the modeling, residential sector, industry, agriculture and power sector are the sectors contributing the most to PM2.5 levels nationwide. While the residential sector is the largest contributor overall, implementing emission controls is most feasible in major point sources in power

[1] https://sites01.lsu.edu/faculty/hlzhang/wp-content/uploads/sites/62/2018/05/Source-apportionment-

plants and industry. As a result, these sectors contribute half of the projected air quality improvements, while being responsible for one quarter of the current pollution levels.

Contribution of vehicular emissions was the largest in Karnataka. Agriculture contributes the most in the northeast. Windblown dust is, predictably, a major contributor to PM2.5 levels in Gujarat and Rajasthan.

Point sources' contribution exceeds one third in Delhi, Maharashtra, Chhattisgarh, Jharkhand and Tamil Nadu, and consequently these states would see the largest benefits from swift and full implementation of emissions standards in power plants and industry.

The 13 policy measures assessed in the report will constitute a major step towards clean air in India. At the same time, in order to ensure safe air for all Indians, substantial further steps will be needed, as PM2.5 levels would remain at unsafe levels in much of the country even after their implementation. Accelerating clean energy and introducing further local policies in critically polluted cities will be key.

The report is collaboration between atmospheric modeling specialists in Louisiana State University and Greenpeace researchers. The data and atmospheric simulations used for the research have been validated in a peer-reviewed article published in the journal Atmospheric Environment[2].

Policy recommendations

To ensure clean air for all Indians, Greenpeace calls on the government to:

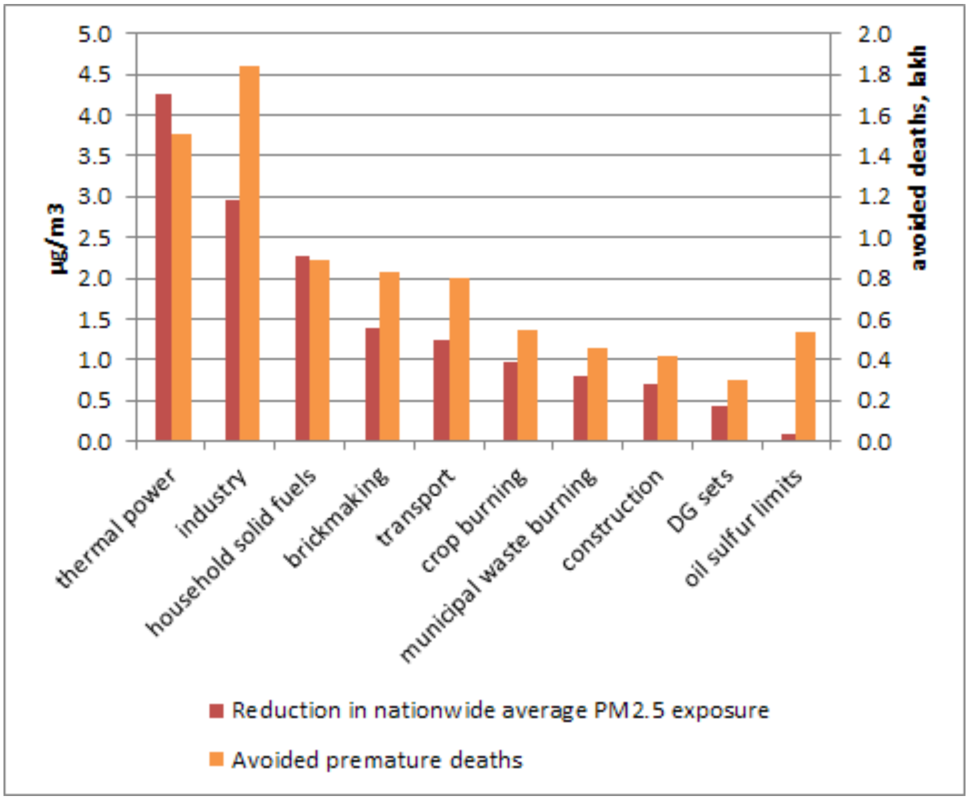
- Set ambitious timelines for reducing PM2.5 levels and meeting national air quality standards across the country, and formulate a policy program that is capable of delivering the targets
- Implement the emission standards for coal based thermal power plants as notified in December 2015 as soon as possible without any further delay[3] and Disclose data on air pollutant emissions from all major point sources in the country on public platforms
- Highlighted in National Electricity Plan 2018,aggressive shutdown of old polluting power plants and prioritising renewable energy sources over coal based power plant for future electricity demand.
- Formulate stricter emission standards with time-bound implementation targets for all industries
- Shift to Zig-Zag technology for brick kilns
- Clean fuel for cooking to every household keeping in perspective the affordability and accessibility to every household moving them away from pollution fuels at household levels. Increase the budget and reach of programs to replace solid fuels in households.
- Eliminate DG-SET usage and encourage solar rooftop options.
- Implement stricter vehicle emissions standards and fuel quality standards, BS-VI across the country by 2020

[2] Kota SH, Guo H, Myllyvirta L, Hu J, Sahu SK, Garagac R, Ying Q, Gao A, Dahiya S, Wang Y & Zhang H, 2018: Year-long simulation of gaseous and particulate air pollutants in India. Atmospheric Environment 180(244-255). https://doi.org/10.1016/j.atmosenv.2018.03.003

[3] http://www.moef.gov.in/sites/default/files/Thermal%20plant%20gazette%20scan.pdf

- Crop residue burning should be eliminated completely by promoting advanced farming methods and improving collection and processing of agricultural residues.
- *B*uilding and improving proper waste management systems, and measures to reduce, reuse and recycle waste should be implemented across the country in aggressive manner.
- Dust control measures at construction sites are assumed to reduce dust emissions by 50% as per CPCB[4]. We assume that these measures can be fully implemented at 50% of all construction sites across the country, which will require a major training and enforcement effort.

Figure 1: Projected reduction in average nationwide PM2.5 exposure (left-hand side) and premature deaths due to air pollution (right hand side), due to emissions reductions achieved in each sector through the 13 policy measures.



[4] p. 136, http://cpcb.nic.in/FinalNationalSummary.pdf

Figure 2: Monthly mean simulated PM2.5 concentrations and reductions in mean concentrations achieved through the 13 emission reduction measures.

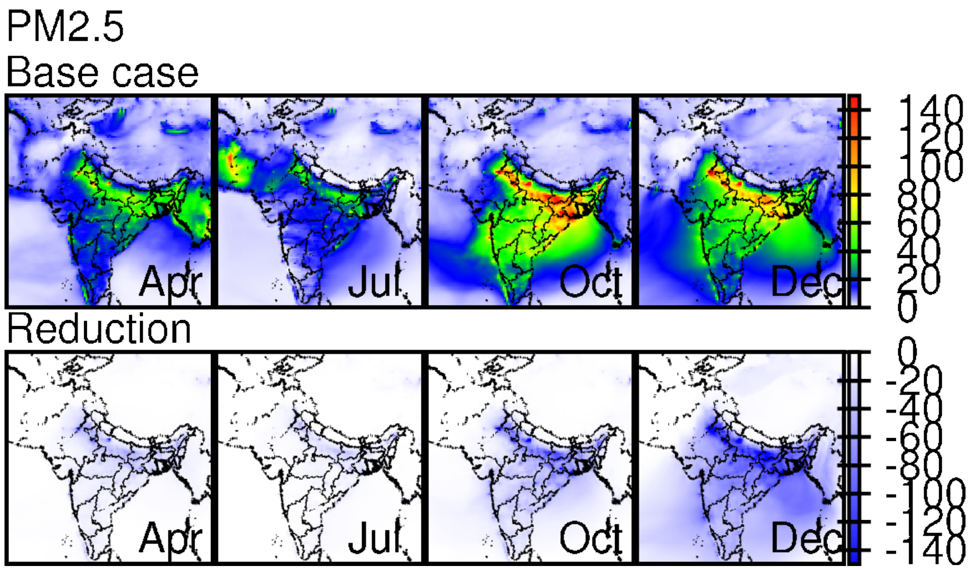


Table 1: Assessed scenarios and avoided premature deaths per year for each scenario.

Policy	Avoided premature deaths per year	Assumed compliance
Implement emission standards on current operating coal-based power plants	-110500	100%
Implement emission standards on under-construction coal-based power plants	-13800	100%
Avoided emissions from cancellation of new coal-fired power plants	-26200	100%
Reduce solid fuels	-88450	50%
Reduce crop burning	-54800	100%
Reduce municipal solid waste burning	-45500	80%
Apply Bharat standards	-47300	100%
Slower oil consumption growth	-32600	100%
Shift to Zigzag kilns	-82700	100%
Stronger oil sulfur limits	-53100	100%
Introduce new emission standards	-184000	50%
Dust control measures	-41600	50%
Reduce diesel generating sets use	-29900	90%

Table 2: Source contribution to premature deaths from chronic diseases in adults

State	Point sources	Residential	Transport	Agriculture	Windblown dust
Andhra Pradesh	32.3%	48.5%	1.3%	11.3%	6.8%
Assam	8.8%	61.3%	0.6%	28.1%	1.3%
Bihar	21.0%	62.0%	0.7%	14.7%	1.2%
Chhattisgarh	35.8%	40.9%	0.7%	18.2%	5.1%
Goa	28.6%	57.1%	0.0%	14.3%	0.0%
Gujrat	27.6%	53.2%	1.7%	6.1%	11.3%
Haryana	32.1%	52.1%	1.4%	10.2%	4.3%
Himachal Pradesh	22.6%	54.8%	3.2%	12.9%	6.5%
Jammu &Kashmir	9.1%	68.2%	0.0%	13.6%	9.1%
Jharkhand	36.4%	48.1%	0.6%	13.3%	2.3%
Karnataka	23.8%	55.0%	3.5%	10.9%	6.9%
Kerala	29.5%	62.5%	1.7%	4.5%	0.6%
Lakshadweep	0.0%	0.0%	0.0%	0.0%	0.0%
Madhya Pradesh	21.4%	55.3%	1.0%	13.4%	9.0%
Maharashtra	35.3%	49.0%	1.1%	8.9%	5.6%
Meghalaya	16.7%	55.6%	0.0%	22.2%	0.0%
Nagaland	12.5%	62.5%	0.0%	25.0%	0.0%
Delhi	45.8%	45.8%	0.8%	5.0%	2.5%
Odisha	32.0%	45.5%	0.8%	18.2%	4.0%
Puducherry	37.5%	50.0%	0.0%	12.5%	0.0%
Punjab	18.0%	57.5%	1.5%	18.8%	4.5%
Rajasthan	14.1%	57.5%	2.0%	9.2%	17.2%
Sikkim	46.3%	46.3%	1.9%	3.7%	1.9%
Tamil Nadu	34.7%	52.9%	1.8%	8.4%	1.8%
Tripura	10.5%	63.2%	0.0%	21.1%	0.0%
Uttar Pradesh	22.8%	61.0%	0.8%	12.9%	2.5%
Uttarakhand	13.2%	65.8%	2.6%	15.8%	5.3%
West Bengal	31.9%	49.5%	0.6%	16.6%	1.3%
India	26.5%	55.5%	1.1%	13.0%	4.0%

Table 3[5]:Projected reduction in PM2.5 levels achieved through the evaluated policies by city[6]

City	Apr	Jul	Oct	Dec	Total
Agra	-54%	-29%	-37%	-55%	-48%
Ahmadabad	-25%	3%	-7%	-52%	-27%
Ajmer	-44%	-16%	-34%	-57%	-45%
Aligarh	-53%	-37%	-41%	-57%	-50%
Allahabad	-47%	-22%	-31%	-51%	-41%
Amravati	-34%	0%	-27%	-51%	-36%
Amritsar	-65%	-45%	-54%	-58%	-56%
Asansol	-38%	-19%	-23%	-47%	-34%
Aurangabad	-32%	4%	-16%	-51%	-30%
Bengaluru	-45%	-50%	-12%	-48%	-35%
Bareli	-62%	-31%	-50%	-66%	-57%
Bhavnagar	-27%	-6%	-4%	-60%	-32%
Bhopal	-52%	-20%	-52%	-61%	-52%
Bhubaneswar	-32%	-23%	-11%	-49%	-29%
Bikaner	-54%	-4%	-42%	-59%	-47%
Mumbai	-27%	-22%	-10%	-40%	-25%
Kolkata	-25%	-14%	-7%	-33%	-19%
Chandigarh	-76%	-62%	-69%	-72%	-70%
Dehra Dun	-75%	-59%	-68%	-67%	-67%
Delhi	-56%	-36%	-47%	-61%	-53%
Durgapur	-28%	-9%	-17%	-41%	-26%
Faridabad	-54%	-32%	-47%	-59%	-51%
Gorakhpur	-58%	-49%	-58%	-65%	-59%
Guntur	-36%	-20%	-16%	-50%	-32%
Guwahati	-53%	-54%	-53%	-61%	-56%
Gwalior	-60%	-32%	-49%	-67%	-58%
Hubli	-46%	-43%	-18%	-58%	-41%
Hyderabad	-37%	-27%	-19%	-47%	-32%
Indore	-54%	-23%	-47%	-66%	-54%
Jabalpur	-57%	-32%	-54%	-61%	-55%
Jaipur	-45%	-18%	-33%	-52%	-43%
Jalandhar	-68%	-44%	-59%	-61%	-59%
Jamnagar	-24%	2%	-7%	-59%	-35%
Jamshedpur	-48%	-32%	-24%	-47%	-37%
Jodhpur	-30%	-7%	-25%	-55%	-38%
Kanpur	-60%	-36%	-46%	-61%	-54%

[5] Based on data in Figure 40 of the detailed report

[6] *Calculated by Greenpeace based on data in Figure 2*

Kochi	-52%	-46%	-20%	-55%	-42%
Kolhapur	-28%	-28%	-9%	-50%	-31%
Kota	-44%	-7%	-40%	-58%	-46%
Koyampattur	-45%	-37%	-1%	-47%	-32%
Lakhnau	-57%	-43%	-53%	-61%	-56%
Ludhiana	-68%	-47%	-62%	-65%	-62%
Chennai	-36%	-34%	-20%	-45%	-34%
Madurai	-46%	-44%	-17%	-52%	-38%
Maisuru	-60%	-55%	-9%	-58%	-40%
Mirat	-56%	-28%	-44%	-53%	-48%
Moradabad	-63%	-40%	-53%	-61%	-57%
Nagpur	-40%	-17%	-33%	-50%	-39%
Nashik	-33%	2%	-18%	-53%	-32%
Patna	-44%	-30%	-24%	-49%	-38%
Pune	-20%	2%	-8%	-37%	-21%
Raipur	-28%	-14%	-29%	-46%	-33%
Rajkot	-25%	-10%	-6%	-57%	-33%
Ranchi	-54%	-38%	-30%	-55%	-44%
Sangli-Miraj	-33%	-28%	-16%	-51%	-35%
Selam	-31%	-25%	-1%	-41%	-24%
Shiliguri	-55%	-40%	-67%	-69%	-62%
Sholapur	-50%	-19%	-27%	-60%	-43%
Srinagar	-81%	-74%	-82%	-81%	-80%
Surat	-17%	2%	3%	-42%	-16%
Thana	-27%	-22%	-10%	-40%	-25%
Thiruvananthapuram	-42%	-31%	-9%	-48%	-32%
Tiruchchirappalli	-38%	-27%	7%	-42%	-26%
Vadodara	-32%	-8%	-19%	-59%	-35%
Varanasi	-53%	-40%	-40%	-54%	-48%
Vijayawada	-28%	-13%	-9%	-42%	-24%
Visakhapatnam	-21%	-12%	0%	-32%	-15%
Warangal	-37%	-20%	-24%	-51%	-34%

Overview of the methodology of the study

Emissions data

A new inventory of air pollutant emissions from different sectors was created for the project. When possible, data from Indian researchers was used, such as in the case of thermal power plants[7], transport sector[8] and municipal waste burning[9]. For household fuel burning, latest official census data[10] on the district level was used and methodology developed by an Indian team of researchers[11] was followed. Emissions data was updated to the latest available fuel consumption or activity data, for example thermal power plant emissions were scaled from 2010 to 2014 based on government data on coal consumption in thermal power plants.

Data recently obtained by Greenpeace India from the CPCB through a Right to Information request indicates that power sector emissions are substantially underestimated in this report and in earlier research.

Emissions reduction scenarios

We identified a total of 13 emissions reduction measures that we judged feasible to implement by 2030 or earlier and that we expected to have significant air quality benefits.

Power plant emissions: We model the full implementation and enforcement of the thermal power plant emissions standards issued in December 2015, in operating and under construction power plants. Full implementation requires both setting strict timelines for plant operators to meet the emissions limits laid out in the regulation, with no further backpedaling, and a strong monitoring and enforcement system that ensures limits are met and excess emissions lead to punishments. Making stack emissions monitoring data public would be an important enforcement step.

Given the recognition that the country has no further need for coal-based generating capacity at least well into 2020s, we also model the avoided emissions from cancelling currently planned coal-based TPP capacity not yet under construction, as identified in the Global Coal Plant Tracker.

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[7] Guttikunda & Jawahar 2014: Atmospheric emissions and pollution from the coal-fired thermal power plants in India. Atmospheric Environment 92:449-460. http://dx.doi.org/10.1016/j.atmosenv.2014.04.057

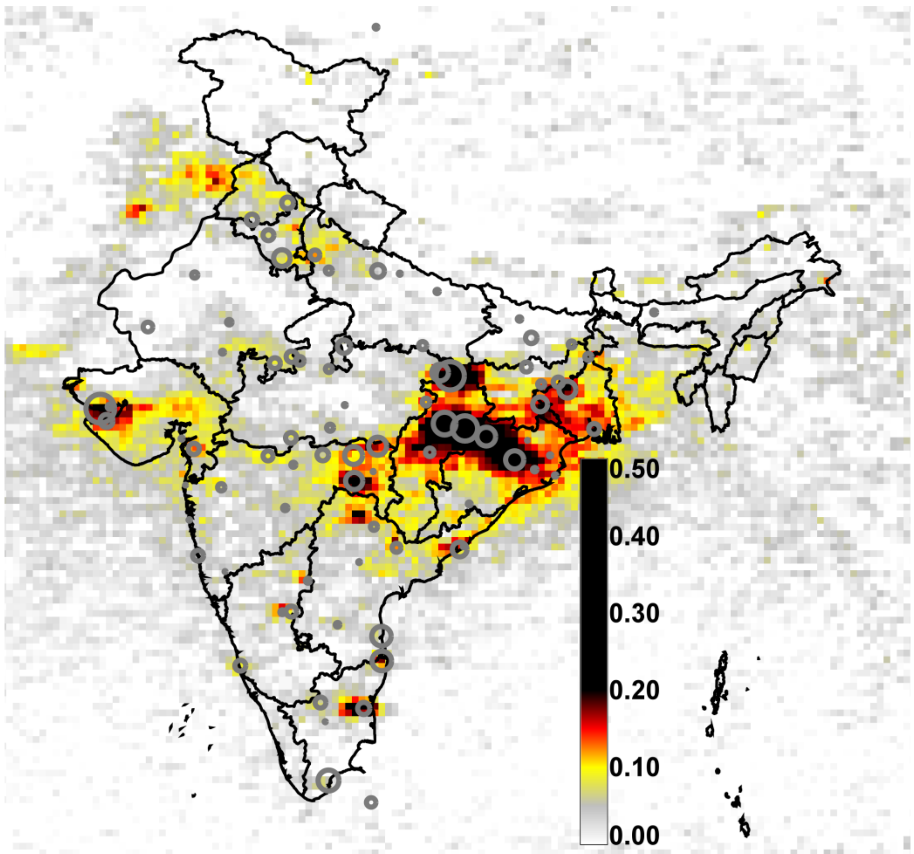
[8] http://dx.doi.org/10.1016/j.enpol.2013.12.067

[9] http://dx.doi.org/10.1080/09593330.2017.1351489

[10] http://www.censusindia.gov.in/2011census/Hlo-series/HH10.html

[11] http://www.sciencedirect.com/science/article/pii/S1352231014007742

Figure 3: Thermal power plants are the dominant source of SO_2 emissions and SO_2 emissions growth in India, as is evident from a map juxtaposing coal-fired power capacity (gray circles) with remote-sensed SO_2 levels[12]. SO_2 is a key contributor to PM2.5 formation.



Industry: *Introduce new emission standards.* We assumed that the same emissions limits that are applied to existing coal-fired power plants in India can be implemented in all industries. This is an ambitious assumption, but in terms of practical implementation and enforcement, controlling stack emissions is much easier than distributed sources. Besides strengthening regulation, implementing this scenario will require major advances in emissions permitting, monitoring and enforcement, including systematically issuing fines to violators. Installing automatic continuous emissions monitoring systems in all major emitting facilities and making emissions data publicly available are key steps to realize the emissions reductions projected in this scenario.

Industry: *Shift to Zigzag kilns.* Current emissions from brick kilns and emissions reductions that can be achieved by shifting to zig-zag kilns were estimated from Rajarathnam et al (2014)[13]. It was assumed that the shift or other measures with equal emission reductions can be achieved in both existing and new kilns.

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[12] Myllyvirta, Dahiya and Sivalingam 2016: Out of Sight: How coal burning advances India's Air Pollution Crisis. http://www.greenpeace.org/india/Global/india/cleanairnation/Reports/Out%20of%20Sight.pdf

[13] http://dx.doi.org/10.1016/j.atmosenv.2014.08.075

Residential: *Reduce solid fuels use.* According to the 2011 census, 16.6 crore households out of a total of 24.7 crore continued to rely on solid fuels (firewood, crop residue, dung and coal) for cooking. This is the single largest source of air pollution in India, affecting both outdoor air quality and indoor air quality, both being major public health concerns. At the same time, cooking is a basic human need and availability and affordability of cooking must be ensured. The vast number of people and households involved, along with the need for solutions that don't burden low-income households economically, makes reducing emissions from this sector a particularly daunting task. Interpolating from GBD MAPS which assumed a virtual elimination of solid fuels in households by 2050, we model a 50% reduction in use of solid fuels by 2030, even as total population is projected to increase by 20%. We believe this to be an ambitious but realistic target.

Residential: *Reduce DG SET use.* We assume that 90% of genset use can be eliminated as level of service on the grid improves.

On road vehicles: *Bharat standards.* Projected emission reductions from accelerated application of the Bharat vehicle emission standards were obtained from Bansal and Bandivadekar (2013)[14]. The air quality benefits are based on the absolute difference in emissions between the "Continued Dual Standards" scenario, representing an extension of current approach, and "World Class" standards scenario, in which India catches up to the most stringent international standards.

On-road vehicles*: Slower oil consumption growth.* We assumed that sustainable transport policies could halve the growth in total oil consumption from 4% to 2% per year.

Industry: *Stronger oil sulfur limits.* We projected absolute emissions reductions from reducing maximum allowed sulfur content in oil to 500 ppm. This measure is administratively simple to implement and has modest cost implications at most, while resulting in substantial health benefits.

Agriculture: *Reduce crop burning.* Both "in-situ crop residue management" and creation of infrastructure and market for the use and management of stubble outside of the field ("ex-situ" management) should be used. Happy Seeder and shift to organic agriculture can serve in helping eliminate biomass burning in agriculture fields. We assume that crop burning can be eliminated completely by promoting advanced farming methods and improving collection and processing of agricultural residues.

Open burning of municipal solid waste*.* We assume that building and improving proper waste management systems, and measures to reduce, reuse and recycle waste can reduce open burning by 80%.

Construction: *Dust control measures.* Dust control measures at construction sites are assumed to reduce dust emissions by 50% as per CPCB[15]. We assume that these measures can be fully implemented at 50% of all construction sites across the country, which will require a major training and enforcement effort.

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[14] http://www.theicct.org/sites/default/files/publications/ICCT_IndiaRetrospective_2013.pdf

[15] p. 136, http://cpcb.nic.in/FinalNationalSummary.pdf

Atmospheric modeling

Source-oriented versions of the Community Multi-scale Air Quality (CMAQ) model with meteorology from the Weather Research and Forecasting (WRF) model were applied to quantify the contributions of different source types to fine particulate matter (PM2.5) and its major components including primary PM (PPM) and secondary inorganic aerosol (SIA) in India in 2015. Then, the health risks were estimated based on the predicted PM2.5 concentrations and the air quality benefits from potential policy interventions in 2030 were analyzed.