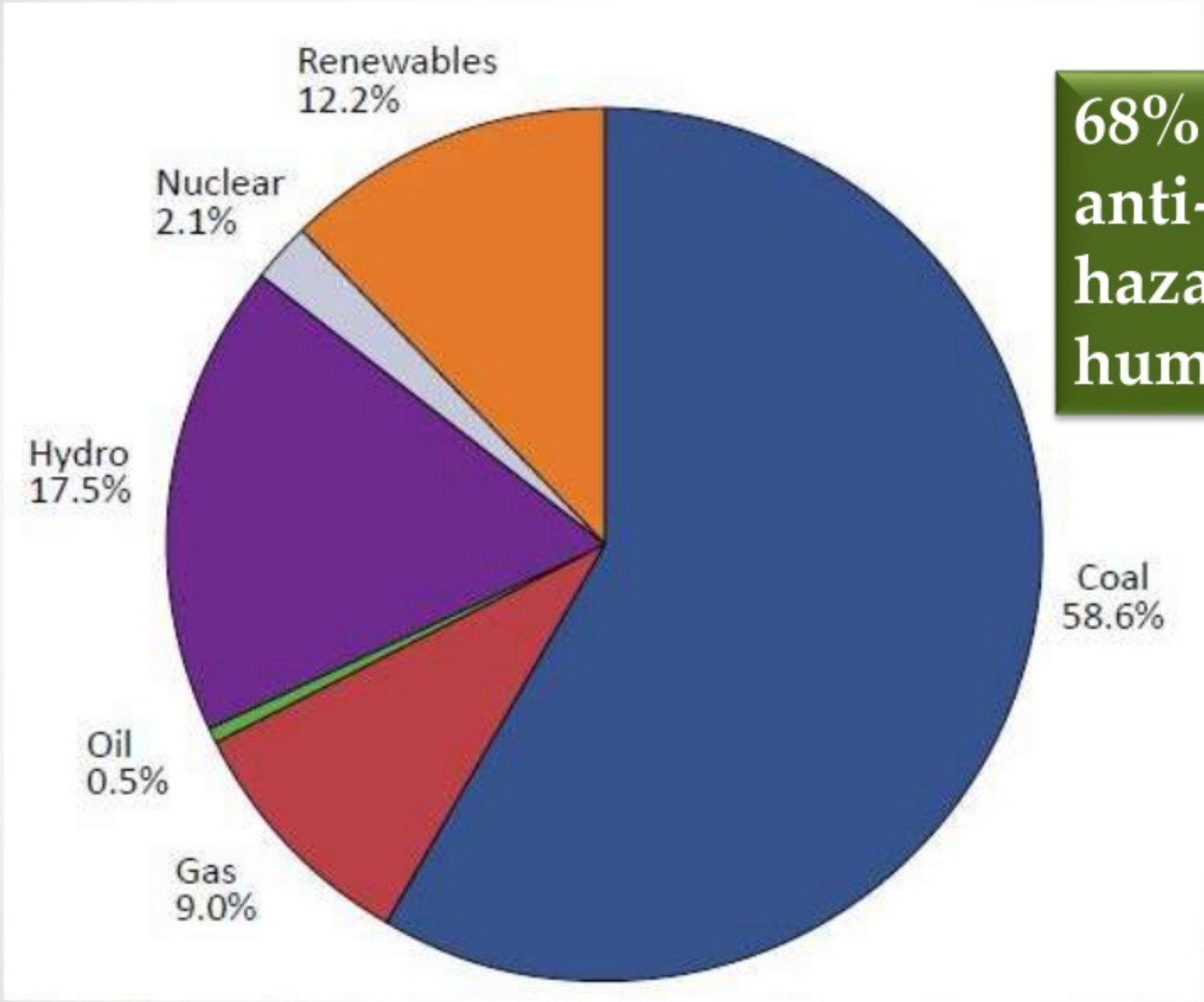
BUILDING SMART RURAL COMMUNITIES IN INDIA

ABCXYZ LTD

Installed Power Generation in India: 2013



68% generation anti-green & hazardous for human health

http://www.worldcoal.org/extract/wp-content/uploads/2014/05/Indian-installed-power-generation-capacity-in-2013.jpg

India's Global Statistics: 2011

Countries (2010)	GNI at PPP ($/capita)*	Energy Consumption (kgoe/capita)	Electricity Consumption (kWh/capita)	Installed Capacity (kW/person)	CO_2 Emissions (tCO_2/capita)	HDI
India	3400	600	641	0.17	1.7	0.52
China	7470	1881	2944	0.74	6.2	0.66
South Africa	10,260	2846	4664	0.89	9.2	0.59
UK	36,020	3241	5746	1.50	7.9	0.85
U.S.	48,880	7962	13,395	3.36	17.6	0.90
World	10,203	1884	2875	0.74	4.6	0.62

*GNI is the gross national income; PPP is the power purchasing parity; kgoe is the kilograms of oil equivalent.

Sources: World Bank database, IEA, and UNDPs Human Development Report 2011.

http://www.worldcoal.org/extract/wp-content/uploads/2014/05/Comparison-of-key-energy-statistics-for-select-countries.jpg

Operating Parameters for a typical 210 MW Coal-fired Power Plant in India

Coal	130 tonnes/hr
Air	700 tonnes/hr
Flue Gas Quantity	800 tonnes/hr
Flue Gas Exit Temperature	140–170°C
Excess Oxygen	3–4%
CO_2 in Flue Gas	13–15%
Moisture in Flue Gas	4–5%
SO_x	700–1200 mg/Nm^3
NO_x	300–500 mg/Nm^3
Particulate	65,000 mg/Nm^3 (before ESP) 120 mg/Nm^3 (after ESP)

http://www.worldcoal.org/extract/wp-content/uploads/2014/05/Operating-parameters.jpg

Fossil Fuel Production & Reserves in India

Source	2011 Production	2011 Consumption	Reserve Estimate*	Energy Resource (EJ)
Coal	540 million tonnes	635 million tonnes	294 billion tonnes (118 billion tonnes proven)	2200–5500
Lignite	42 million tonnes	42 million tonnes	41 billion tonnes	490
Oil	38 million tonnes	211 million tonnes	760 million tonnes	32
Natural Gas	48 billion m^3	46 billion m^3	1330 billion m^3	47

*2013 estimate based on a geological survey of India.

http://www.worldcoal.org/extract/wp-content/uploads/2014/05/Fossil-fuel-production-and-reserves-in-India.jpg

Comparison of Centralized Electricity Generation Options for India

Source	Capital Cost* (million/MW)	Gestation Period (years)	Availability (maximum capacity factor)	Cost of Generation (INR/kWh)	Land Area (m^2/MW)
Coal	INR50/MW US$1/MW	5	92%	INR3/kWh 6 US¢/kWh	2000
Gas	INR40/MW US$0.8/MW	3	95%	INR3.5–4/kWh 7–8¢/kWh	N/A**
Nuclear	INR70/MW US$1.4/MW	7	80%	INR4/kWh 8 US¢/kWh	1200–4700
Hydro	INR60/MW US$1.2/MW	6	50–60%	INR2.5–3.50/kWh 5–7 US¢/kWh	222,000
Solar PV	INR120/MW US$2.4/MW	1	25%	INR10/kWh 20 US¢/kWh	12,000
Solar Thermal	INR150/MW US$3.0/MW	2	26%	INR15/kWh 30 US¢/kWh	20,000
Wind	INR60/MW US$1.2/MW	1–2	30%	INR4–6/kWh 8–12 US¢/kWh	100

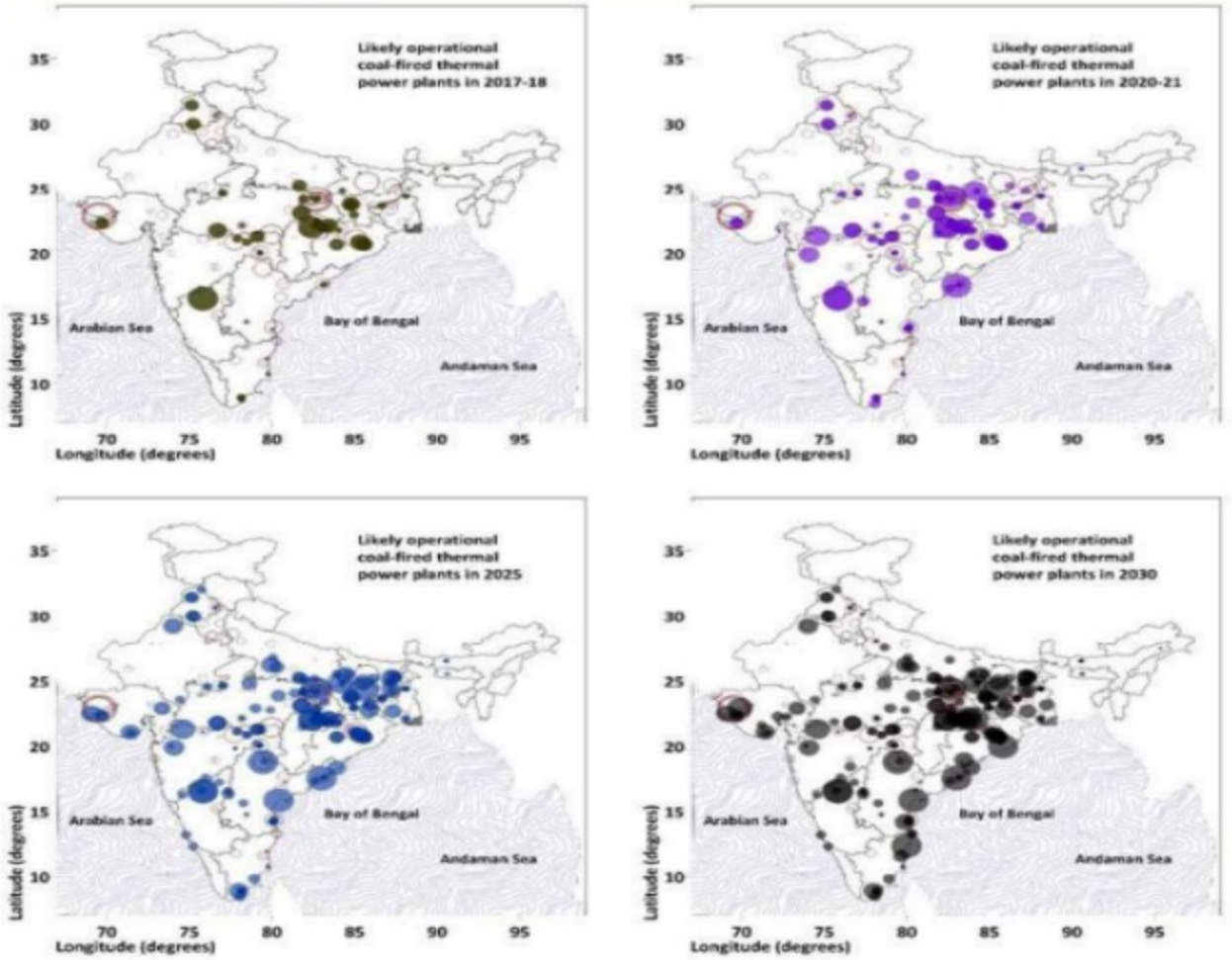
*Computed at 2012 exchange rate of INR50/US$.
**Data not readily available for India, but estimated by author to be 1000 m^2/MW.

http://www.worldcoal.org/extract/wp-content/uploads/2014/05/Comparison-of-centralized-electricity-generation-options-for-India.jpg

Concentrator PV Power Plant installed by Concentrix Solar

Projected Growth of TPPs in India till 2030 - I

Figure 8: Proposed locations of the coal-fired TPPs in India through 2030. The brown circles represent the TPPs operational in 2014 (details in Figure 6) and the second colour in each map represents all the new plants and expansions expected after 2014 and likely to be operational in the representative year. The largest circle is 4620MW. Note that many of these circles are overlapping due their close proximity to other TPPs



http://www.urbanemissions.info/images/stories/Air%20Pollution%20from%20India%20Coal%20TPPs%20-%20Coal%20Power%20Expansion.jpg

Projected Growth of TPPs in India till 2030 - II

- Total coal consumption is estimated to increase 2-3 times from 660 million tons/year to 1800 million tons/year; accordingly the CO2 emissions from 1,590 million tons/year to 4,320 million tons/year
- PM, SO2, and NOx emissions will at least double in the same period. Most of the planned plants are supercritical- and ultra- TPPs, which tend to utilize less coal per MWh of electricity generated
- With no emission regulations in place for SO2 and NOx, these are assumed uncontrolled and allowed to release through the elevated stacks for dispersion
- 100% increase in health impacts - The total premature mortality due to the emissions from coal-fired TPPs is expected to grow 2-3 times reaching 186,500 to 229,500 annually in 2030. Asthma cases associated with coal-fired TPP emissions will grow to 42.7 million by 2030
- Limited emission standards for power plants - India currently has no standards for either SO2 or NOx both of which drive a large portion of the estimated these health impacts – in the form of secondary sulphates and secondary nitrates.

http://www.urbanemissions.info/india-power-plants

Projected Growth of TPPs in India till 2030 - III

- Set emission standards
- Mandate FGD at the plant level
- Practice rigorous monitoring
- Ensure transparency
- Improve EIA
- Large enforcement /redesign costs

http://www.urbanemissions.info/india-power-plants

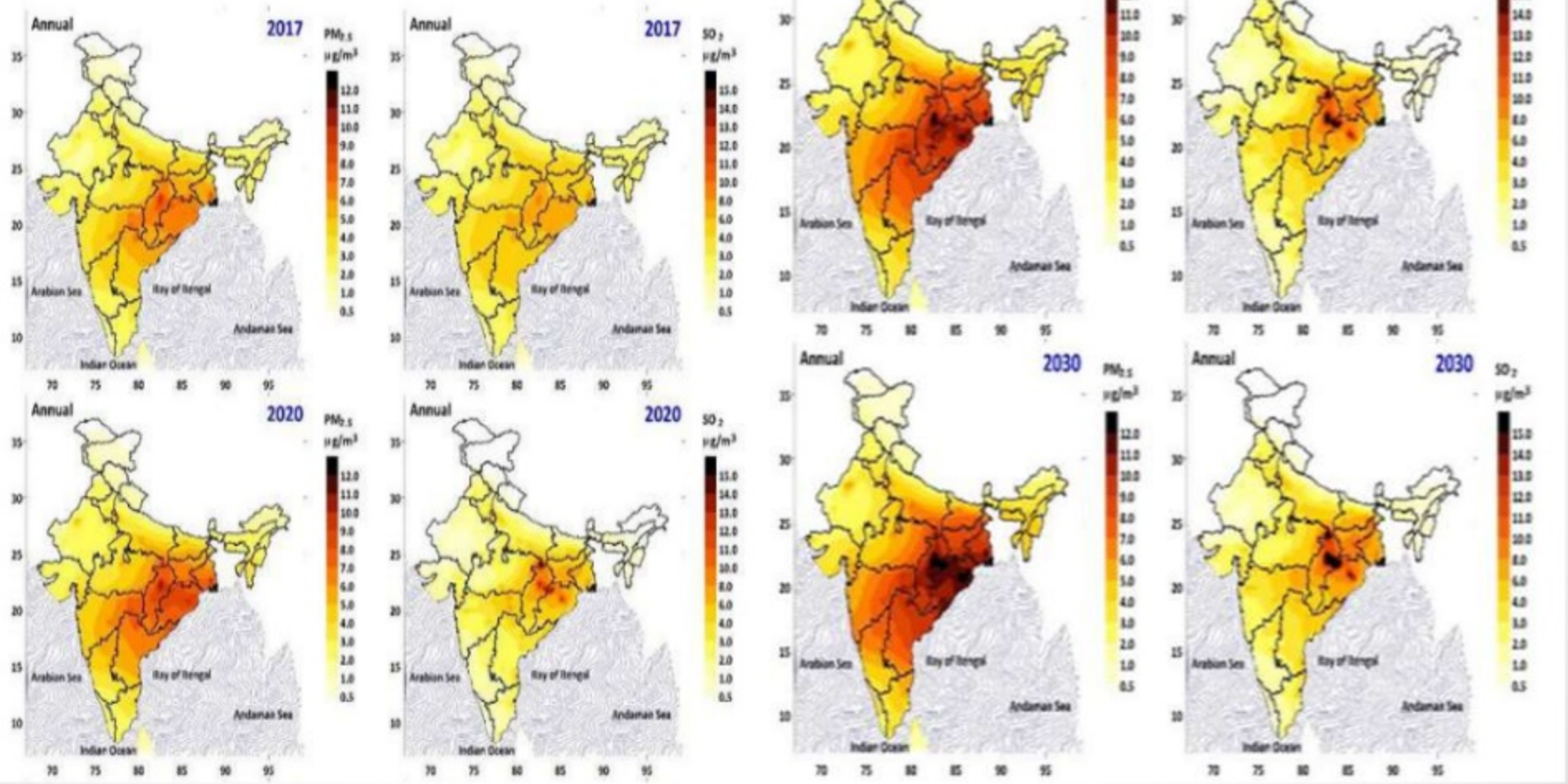
Shifting Emphasis to Renewable Energy

- Over the last 40 years thermal generation has increased to more than 70%
- Given the difficulty of constructing large hydro projects, its share is unlikely to increase in the future
- Nuclear installed capacity is projected to increase to about 69 GW (under the most optimistic scenario) from the existing base of about 5 GW
- Share of coal in the electricity generation mix is likely to range from 50 – 60% in 2035
- Scenario whereby India reduces the coal mix to 40% is considered as the highest possible reduction in coal usage would imply a 22% share of renewable energy in the electricity generation mix
- Even with this high renewable share, the coal installed capacity must grow to 270 GW by 2035
- More likely estimate of installed coal-based power capacity is 340 GW (50% share) in 2035, which represents significant growth from the existing installed capacity of 132 GW in 2013 (i.e., growth rate of 4.4% per year).

http://www.worldcoal.org/extract/coal-based-electricity-generation-in-india-3700/

The Rising Health Hazard from TPPs till 2030 - I

Figure 10: Modelled annual average $PM_{2.5}$ and SO_2 concentrations ($\mu g/m^3$) from the coal-fired TPPs in India

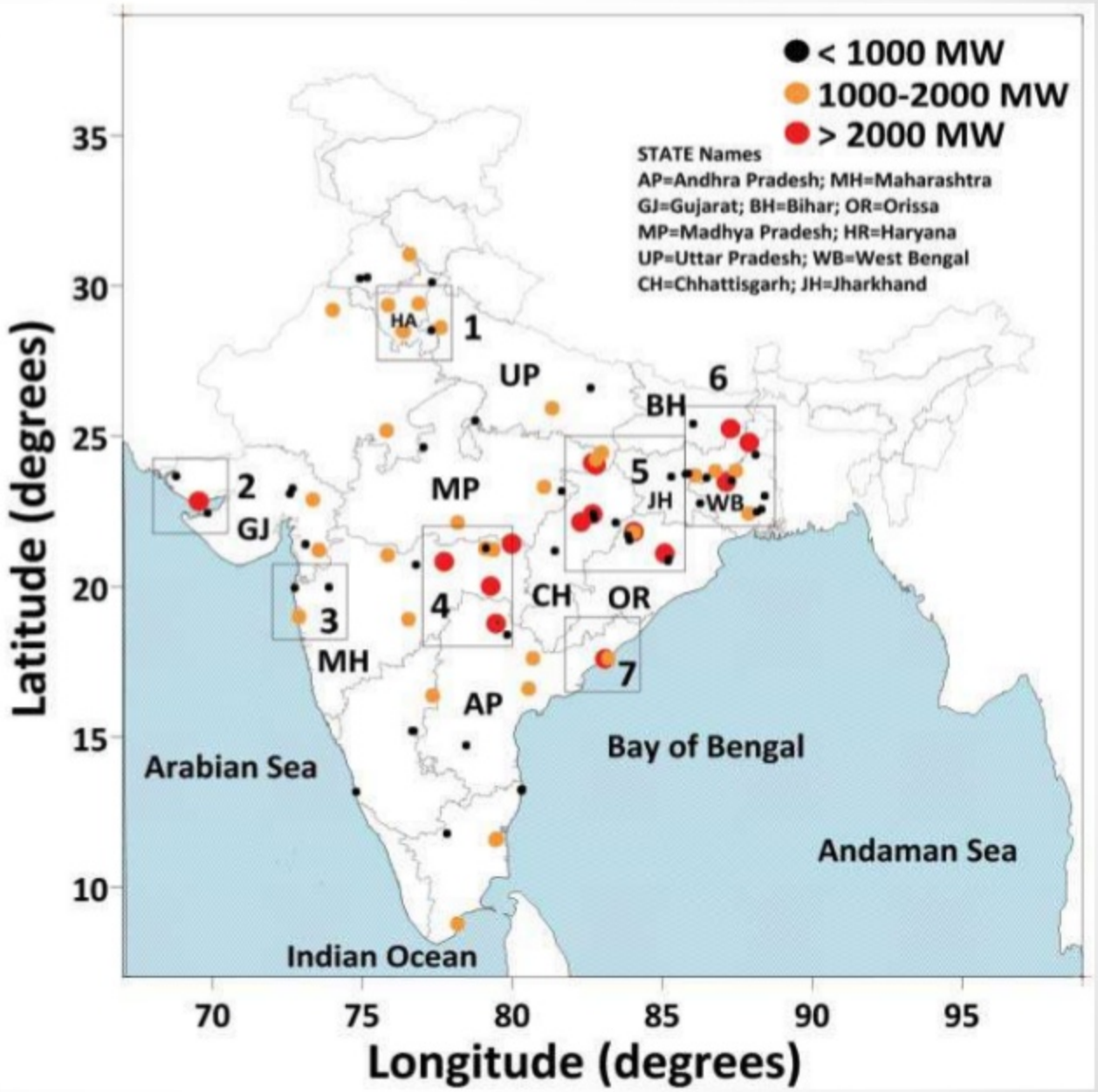


http://www.urbanemissions.info/images/stories/Air%20Pollution%20from%20India%20Coal%20TPPs%20-%20PM%20and%20SO2%20pollution%20through%202030.jpg

The Rising Health Hazard from TPPs till 2030 - II

Largest impact:

- ❑ Delhi
- ❑ Haryana
- ❑ Maharashtra
- ❑ Madhya Pradesh
- ❑ Chhattisgarh
- ❑ Indo-Gangetic Plain
- ❑ Central-East India



Debi Goenka & Sarath Guttikunda, Coal Kills An Assessment of Death and Disease caused by India's Dirtiest Energy, Urban Emissions & Greenpeace India, 2014, p. 7

Health Impact of Coal-Based Power Generation - I

Table 6: Modelled state average $PM_{2.5}$ concentrations (indicative of the pollution load) due to the emissions from the coal-fired TPPs

	2017	2020	2025	2030
Andhra Pradesh	4.9 ± 0.9 (8.5)	6.1 ± 1.1 (9.8)	7.5 ± 1.3 (11.6)	8.4 ± 1.5 (13)
Arunachal Pradesh	1.6 ± 0.3 (2.0)	2.0 ± 0.4 (2.4)	2.5 ± 0.5 (3.0)	2.9 ± 0.6 (3.5)
Assam	2.1 ± 0.3 (2.6)	2.6 ± 0.4 (3.2)	3.3 ± 0.5 (4.1)	3.8 ± 0.6 (4.6)
Bihar	3.7 ± 1 (6.0)	4.3 ± 1.2 (6.5)	5.5 ± 1.7 (7.7)	6.1 ± 1.9 (8.8)
Chhattisgarh	6.6 ± 0.9 (12.7)	8.0 ± 1.0 (14.0)	9.6 ± 1.1 (16.0)	10.6 ± 1.2 (16.9)
Delhi	4.1 ± 1 (5.8)	4.3 ± 1.0 (6.0)	4.7 ± 1.0 (6.4)	5.0 ± 1.0 (6.8)
Goa	3.6 ± 0.1 (3.8)	4.4 ± 0.1 (4.6)	5.4 ± 0.1 (5.6)	6.0 ± 0.1 (6.2)
Gujarat	3 ± 0.7 (5.7)	3.3 ± 0.8 (6.2)	3.9 ± 0.9 (7.0)	4.2 ± 1 (7.5)
Haryana	3.3 ± 0.7 (5.8)	3.5 ± 0.7 (6.0)	3.9 ± 0.8 (6.4)	4.2 ± 0.8 (6.8)
Himachal Pradesh	1.4 ± 0.4 (2.1)	1.5 ± 0.4 (2.2)	1.8 ± 0.5 (2.5)	1.9 ± 0.6 (2.7)
Jammu & Kashmir	0.9 ± 0.2 (1.4)	1.0 ± 0.3 (1.5)	1.2 ± 0.3 (1.8)	1.2 ± 0.3 (1.9)
Jharkhand	5.2 ± 0.7 (10.1)	6.2 ± 0.9 (11.5)	8.0 ± 0.9 (13.3)	8.8 ± 0.9 (14.3)
Karnataka	3.3 ± 0.8 (5.5)	4.1 ± 1.0 (6.4)	5.1 ± 1.2 (7.5)	5.7 ± 1.3 (8.2)
Kerala	1.9 ± 0.2 (2.6)	2.3 ± 0.3 (3.2)	2.9 ± 0.4 (4.0)	3.3 ± 0.4 (4.5)
Madhya Pradesh	3.7 ± 0.9 (8.2)	4.4 ± 1.2 (8.7)	5.2 ± 1.4 (10.0)	5.6 ± 1.5 (10.8)
Maharashtra	4.4 ± 0.9 (9.3)	5.2 ± 1.1 (10.6)	6.3 ± 1.3 (12.1)	6.8 ± 1.4 (12.9)
Manipur	2.4 ± 0.1 (2.6)	2.9 ± 0.1 (3.2)	3.7 ± 0.2 (4)	4.1 ± 0.2 (4.5)
Meghalaya	2.4 ± 0.1 (2.8)	2.9 ± 0.1 (3.3)	3.8 ± 0.2 (4.4)	4.3 ± 0.2 (5.0)
Mizoram	2.5 ± 0.1 (2.6)	3.1 ± 0.1 (3.2)	3.9 ± 0.1 (4)	4.4 ± 0.1 (4.5)
Nagaland	2.1 ± 0.1 (2.4)	2.6 ± 0.2 (2.9)	3.2 ± 0.2 (3.7)	3.7 ± 0.2 (4.2)
Odisha	6.4 ± 0.6 (10.1)	8.1 ± 0.7 (11.5)	10.1 ± 0.9 (13.6)	11.2 ± 0.9 (15.0)
Punjab	1.9 ± 0.3 (2.7)	2.1 ± 0.3 (2.8)	2.4 ± 0.4 (3.2)	2.6 ± 0.4 (3.4)
Rajasthan	2.4 ± 0.6 (6.3)	2.7 ± 0.7 (7.6)	3.1 ± 0.8 (8.1)	3.3 ± 0.8 (8.2)
Sikkim	1.4 ± 0.3 (1.6)	1.7 ± 0.4 (1.9)	2.1 ± 0.5 (2.4)	2.3 ± 0.6 (2.6)
Tamilnadu	2.6 ± 0.5 (5.2)	3.1 ± 0.7 (5.6)	3.9 ± 0.8 (6.3)	4.4 ± 0.9 (6.8)
Tripura	2.6 ± 0.1 (2.8)	3.2 ± 0.1 (3.4)	4.2 ± 0.1 (4.4)	4.7 ± 0.2 (5.0)
Uttar Pradesh	3.2 ± 1.1 (7.4)	3.6 ± 1.4 (8.6)	4.3 ± 1.6 (10.0)	4.7 ± 1.8 (10.8)
Uttarakhand	1.4 ± 0.3 (1.8)	1.6 ± 0.4 (2.0)	1.9 ± 0.4 (2.3)	2.0 ± 0.5 (2.5)
West Bengal	6.0 ± 1.6 (12.9)	7.1 ± 1.9 (14.1)	8.8 ± 2.3 (16.0)	9.7 ± 2.6 (17.0)

The concentrations are in $\mu g/m^3$ and the data represents - population weighted state average concentration ± standard deviation of concentrations for all grids covering the state and (in the brackets – maximum concentration among the grids covering the state) The model grid size is 0.25 degrees (~25km x 25km). Because of this spatial coverage, these numbers cannot be directly compared to the data from the monitoring stations, which only represent their immediate vicinity.

- http://www.urbanemissions.info/images/stories/Air%20Pollution%20from%20India%20Coal%20TPPs%20-%20Population%20Weighted%20PM2.5.jpg

Health Impact of Coal-Based Power Generation - II

Table 7: Anticipated health impacts due to ambient $PM_{2.5}$ pollution from the proposed coal-fired TPPs in India		
	Premature mortality	Asthma attacks
Year 2017-18	112,500 – 126,000	23.4 million
Year 2020-21	132,500 – 153,500	28.4 million
Year 2025	164,000 – 197,500	36.7 million
Year 2030	186,500 – 229,500	42.7 million

http://www.urbanemissions.info/images/stories/Air%20Pollution%20from%20India%20Coal%20TPPs%20-%20Anticipated%20Health%20Impacts.jpg

Health Impact of Coal-Based Power Generation - III

Table 9: Anticipated health impacts of planned coal-fired TPPs and likely number of lives saved by operating a flue gas desulphurization unit at all the coal-fired TPPs in India

	Premature mortality under no FGD	Lives saved under 60%- and 95%- FGD efficiency	Monetary benefits under FGD (crores)
Year 2017	112,500 – 126,000	39,000 – 63,000	7,800 – 12,600
Year 2020	132,500 – 153,500	45,000 – 74,000	9,000 – 14,800
Year 2025	164,000 – 197,500	54,500 – 90,500	10,900 – 18,100
Year 2030	186,500 – 229,500	61,000 – 101,500	12,200 – 20,300

http://www.urbanemissions.info/images/stories/Air%20Pollution%20from%20India%20Coal%20TPPs%20-%20Benefits%20of%20FGD.jpg

Health Impact of Coal-Based Power Generation - IV

Table 8: Estimated health impacts by state due to $PM_{2.5}$ pollution from the coal-fired TPPs in India				
	2017	2020	2025	2030
Andhra Pradesh	9,870	12,170	15,170	17,510
Arunachal Pradesh	70	90	110	130
Assam	1,780	2,160	2,800	3,300
Bihar	9,450	11,070	14,410	16,410
Chhattisgarh	3,870	4,610	5,600	6,340
Delhi	1,520	1,640	1,880	2,090
Goa	120	140	180	200
Gujarat	4,300	4,880	5,890	6,690
Haryana	2,080	2,260	2,630	2,940
Himachal Pradesh	280	300	370	410
Jammu & Kashmir	360	400	480	530
Jharkhand	4,120	4,940	6,340	7,190
Karnataka	5,170	6,340	7,940	9,160
Kerala	1,660	2,000	2,530	2,980
Madhya Pradesh	6,790	7,970	9,700	10,940
Maharashtra	11,580	13,860	16,870	19,010
Manipur	180	220	280	330
Meghalaya	190	230	300	350
Mizoram	70	90	110	130
Nagaland	130	160	200	230
Odisha	6,100	7,560	9,380	10,740
Punjab	1,470	1,600	1,920	2,140
Rajasthan	4,340	4,860	5,800	6,510
Sikkim	30	30	40	50
Tamilnadu	5,080	6,110	7,650	9,020
Tripura	200	240	320	370
Uttar Pradesh	16,470	18,740	22,870	26,000
Uttarakhand	390	440	540	610
West Bengal	12,360	14,470	18,060	20,440

http://www.urbanemissions.info/images/stories/Air%20Pollution%20from%20India%20Coal%20TPPs%20-%20Health%20Impacts%20by%20State.jpg

Health Impact of Coal-Based Power Generation - V

Health impacts resulting in premature deaths include

- **Chronic obstructive pulmonary disease**
- **Lower respiratory infections**
- **Cerebrovascular disease**
- **Ischemic heart disease**
- **Cancers of trachea, bronchitis, and lung**
- **Systemic inflammation**
- **Accelerated atherosclerosis**
- **Altered cardiac function**

Debi Goenka & Sarath Guttikunda, Coal Kills An Assessment of Death and Disease caused by India's Dirtiest Energy, Urban Emissions & Greenpeace India, 2014, p. 4

Annual Health Impact of Coal-Based Power Generation

Effect	Health Impacts (Heads)	Impact Cost
Total Premature Mortality	80000-115000	INR 16-23,000 crore (USD 3.3-4.6 b)
Child Mortality (<5 yrs.)	10,000	INR 2100 crore (USD 420 m)
Respiratory Symptoms	625 million	INR 6200 crore (USD 1.2 b)
Chronic Bronchitis	170000	INR 900 (USD 170 m)
Chest Discomforts	8.4 million	INR 170 crore (USD 35 m)
Asthma Attacks	20.9 million	INR 2100 crore (USD 420 m)
Emergency room visits	9,00,000	INR 320 crore (USD 60 m)
Restricted Activity Days	160 million	INR 8000 crore (USD 1.60 b)
Total		USD 7.21-8.49 = INR 35790-42790 crore/annum
Cost/unit for 100 billion consumable units/annum	-	INR 0.23-0.28

Sarath K. Guttikunda & Puja Jawahar: Atmospheric emissions and pollution from the coal-fired thermal power plants in India, Atmospheric Environment 92 (2014) 449-460, Elseiver, 2014

Debi Goenka & Sarath Guttikunda, Coal Kills An Assessment of Death and Disease caused by India's Dirtiest Energy, Urban Emissions & Greenpeace India, 2014

Should India Depend on Coal?

- Coal is probably the least expensive fossil fuel for power generation or for industrial use based on the cost per unit energy content in India
- The price of coal is on the order of INR170/GJ (US$3.2/GJ) as compared to INR1000/GJ for fuel oil (US$20/GJ) or INR240/GJ (US$4.8/ GJ) for natural gas
- Share of imports in the Indian energy supply mix has been increasing over the last two decades. In 2012 energy imports accounted for about 26% of the total primary energy supply, mainly due to oil imports
- India imported about 124 million tons of crude oil and about 23 million tons of petroleum products with exports of about 41 million tons of petroleum products in 2010
- India's oil production has been nearly stagnant at about 33–38 million tons annually
- Foreign exchange rate fluctuation (devaluation of the rupee) results in a major impact on the economy with an increase in oil prices and resultant inflationary pressure (in 2013 the $-rupee exchange rate increased from 50INR/US$ to 64INR/US$).

http://www.worldcoal.org/extract/coal-based-electricity-generation-in-india-3700/