



Coal power - overview

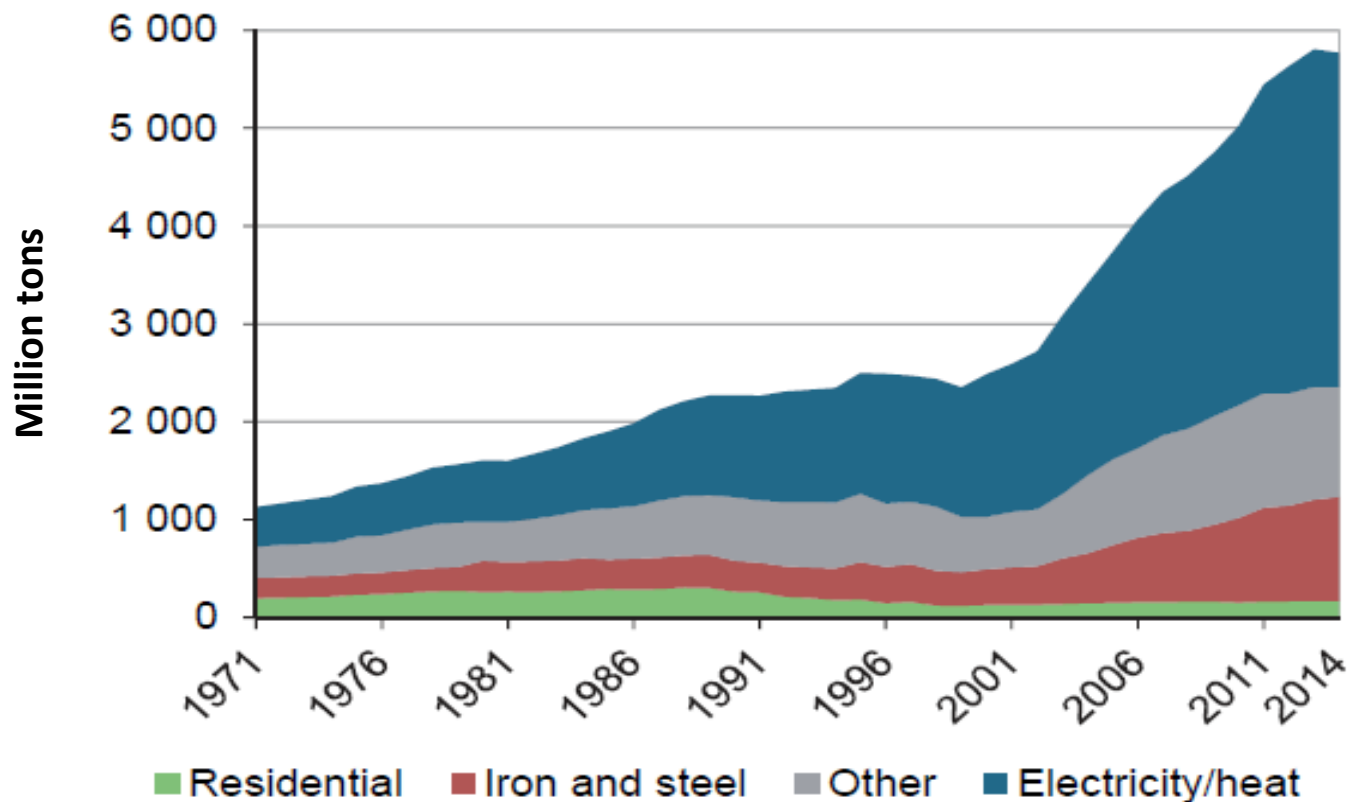
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Coal and Power – Intertwined

- Non OECD - 60% of coal used for power generation; Steel and other industry is another 30%.
 - Conversely, 75-80% of power generated by coal in China, India
- OECD – 80% of coal for power and residential; industry use declining
 - coal contributes declining share (~30%) of electricity (RE, gas, nuclear..)





Coal Use – Asia's share

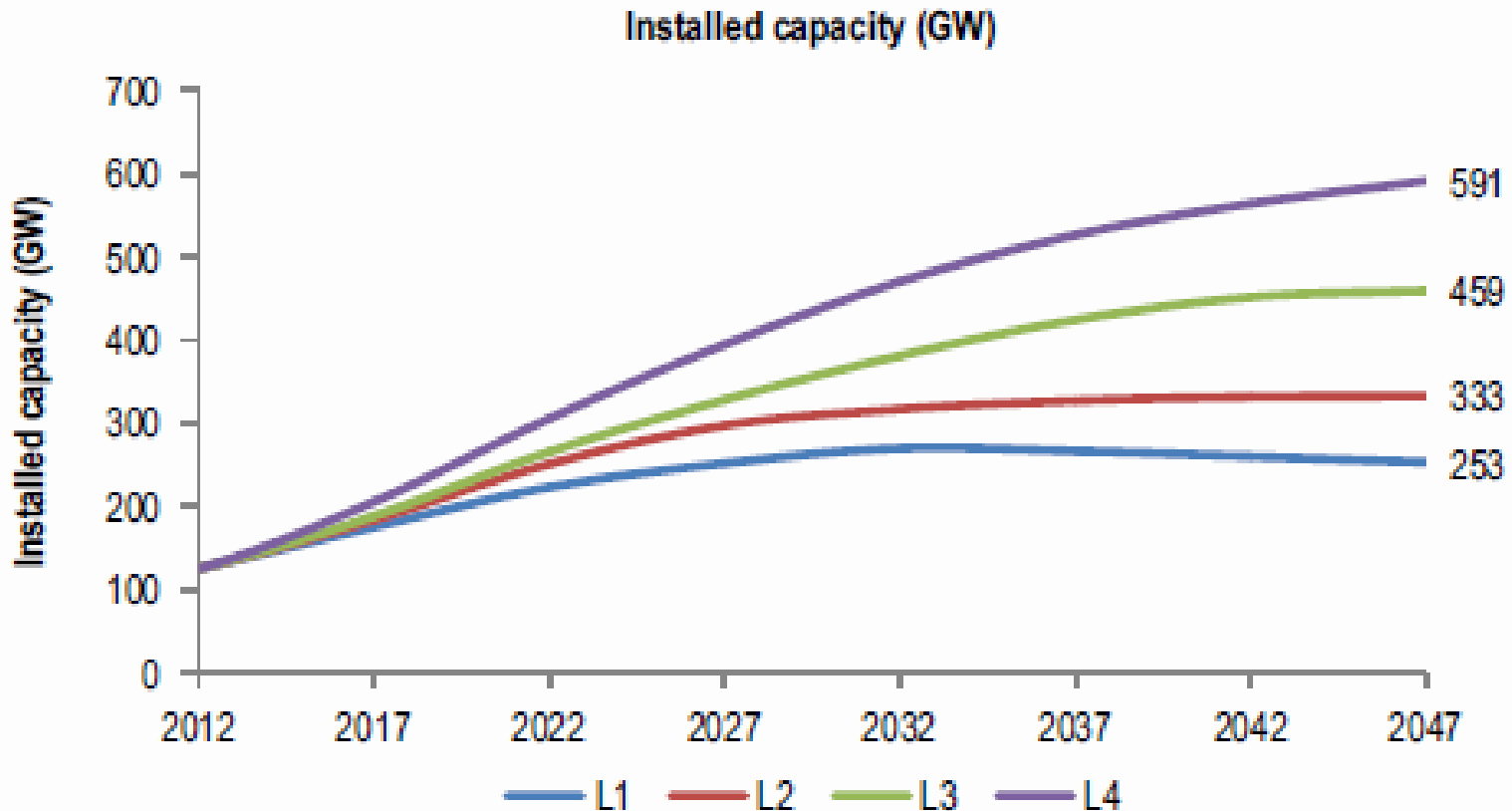
- In 2015 coal use fell 2.6%; Use in OECD (~25%; dropped over 6% - gas)
- Asia dominant user with coal based power capacity increasing
 - Adds: Indonesia 42GW by 2025; Malaysia 4.6GW by 2020; Vietnam – 50GW by 2030; India - +80GW by 2021

OECD (Mtce)	2012	2013	2014	% share
United States	607	618	616	11.1%
Japan	161	172	165	3.0%
Korea	110	111	115	2.1%
Germany	112	114	109	2.0%
Major Asia				
China	2,690	2,920	2,836	51.2%
India	453	484	551	9.9%
Taiwan	56	58	59	1.1%
Indonesia	43	45	47	0.8%
Thailand	23	25	26	0.5%
Vietnam	23	22	25	0.4%
Malaysia	23	22	24	0.4%
Sub total	3,311	3,575	3,567	64%
World	5,331	5,593	5,544	



Coal capacity peaking ?

- **Projected by NITI Aayog (fka Planning Commission)**
 - L2 “most likely under current policies” 297GW by 2027 based projected growth for the next decade; rising slowly to 333GW in 2047
 - L3 “aggressive scenario) – 381GW by 2032
 - Peaks? -Indonesia - 75GW (2025); Vietnam - 62GW (2030); Malaysia – 15GW (2020)





Way forward HELE plants

- Coal may continue to grow in Asia
- High Efficiency plants: CO₂ 30% lower (India avg 1.08Kg/KWh)
- SO_x/NO_x can be cut by over 90%

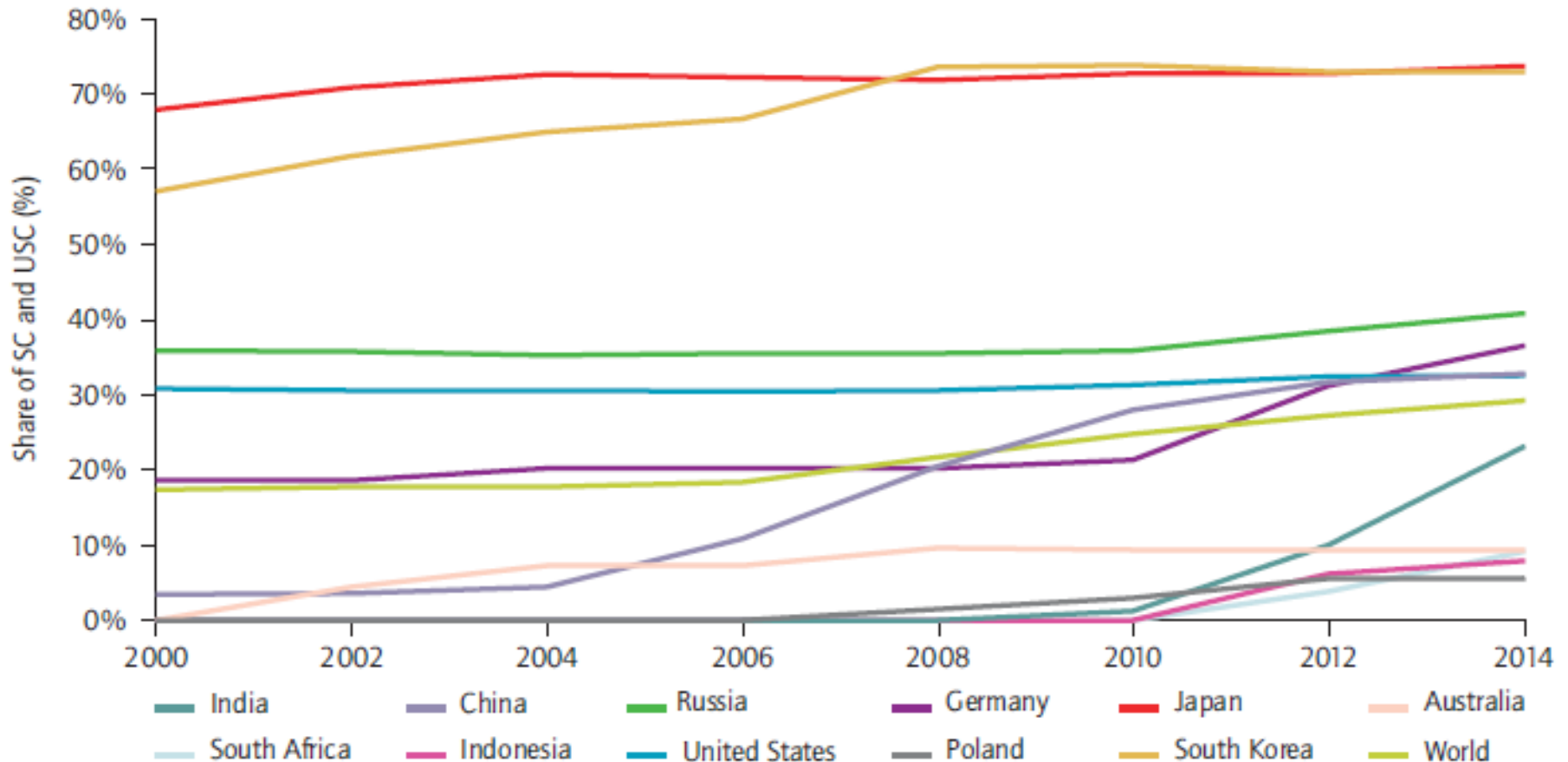
Fuel type	Plant type	CO ₂ (g/kWh)	Emissions in mg/Nm ³			Max. unit capacity (MW _e)	Capacity factor (%)	CCS energy penalty (%-points)
			NO _x	SO ₂	PM			
Coal	PC (USC)	740	<50 to 100 (by SCR)	<20 to 100 (by FGD)	<10	1100	80	7 to 10 (post-combustion and oxy-fuel)
	CFBC	880 to 900	<200	<50 to 100 (in situ)	<50	460	80	
	PC (A-USC) ¹	670 (700°C)	<50 to 100 (by SCR)	<20 to 100 (by FGD)	<10	<1000 (possible)	-	
	IGCC	670 to 740	<30	<20	<1	335	70	

¹ Under development



SC & USC capacity in major countries

- Low penetration of SC and USC in emerging Asian countries (China – 30%; India 20%; Indonesia 8%; Malaysia 12%)
- But, accelerating – India (3GW before 2011; 32GW in 2012-16); Malaysia (1GW operating, 3GW in pipeline)
- IEA projects that of ~1000GW capacity in 2050, half will be sub critical – continued capacity built till 2020. 2DS scenario requires ~800GW HELE





Pollution impact – India perspective

COAL CONSUMPTION: Around 75% of total use (over 700 mt in 2011-12)

WATER WITHDRAWAL: around 24 bcm, close to half of total domestic needs

AIR POLLUTION: of Indian industrial sector's

- 60% of PM emissions (includes coal mining)
- 45% of SO₂ emissions
- 30% of NO_x emissions
- 80% of Hg emissions

GHG EMISSION: over 50 % (1.1 Bt) of India's total CO₂ from fuel combustion

WASTE: Ash is the second largest waste stream

- 1 bt ash stored in ash ponds in India
- 180 mt annual generation, of which 60 mt is being dumped in ash ponds
- Responsible for severe **WATER POLLUTION** as well

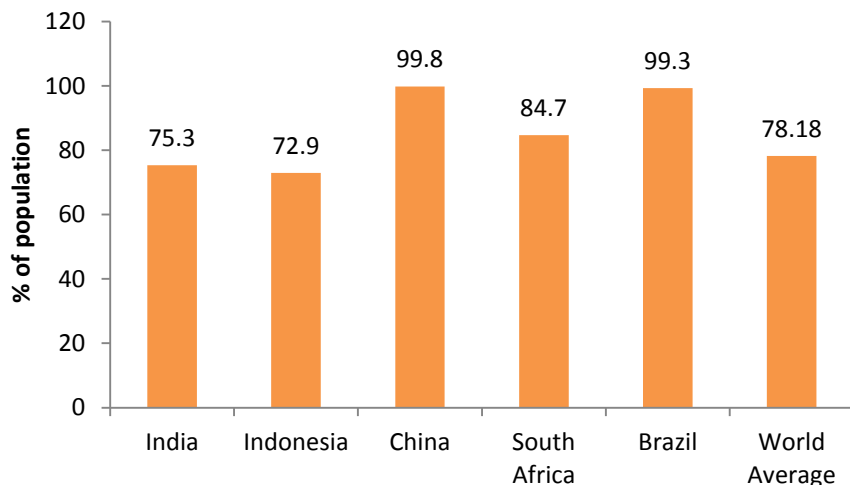
These problems will worsen under “business as usual” scenario as coal-based capacity will increase to 260GW by 2021...



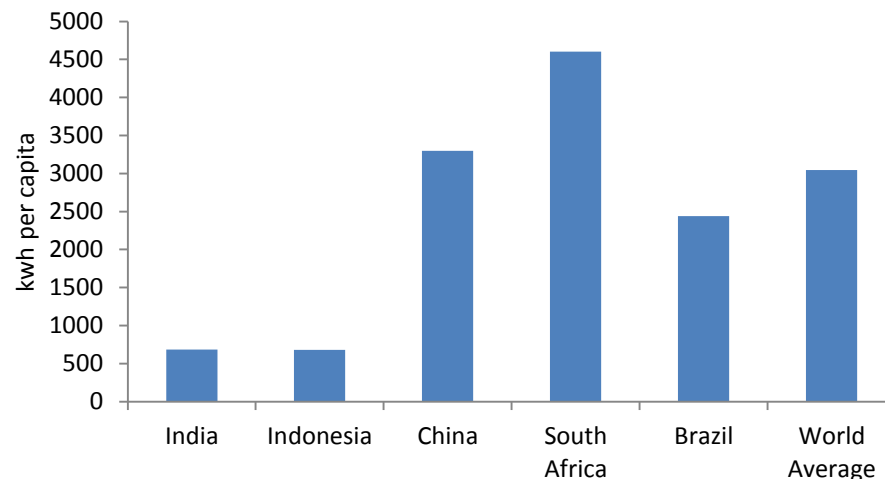
Electricity access & consumption

- 25% population without access to electricity; large numbers get intermittent supply
- Lowest per capita electricity use amongst major economies (~1000 KWh/p.a. , third of the world average)
- Almost 75% of power generated by coal plants (186GW current capacity)
- Growing demand will be largely met with coal - 260GW by 2021
- Strong renewables push (175 GW plan); but will remain small contributor

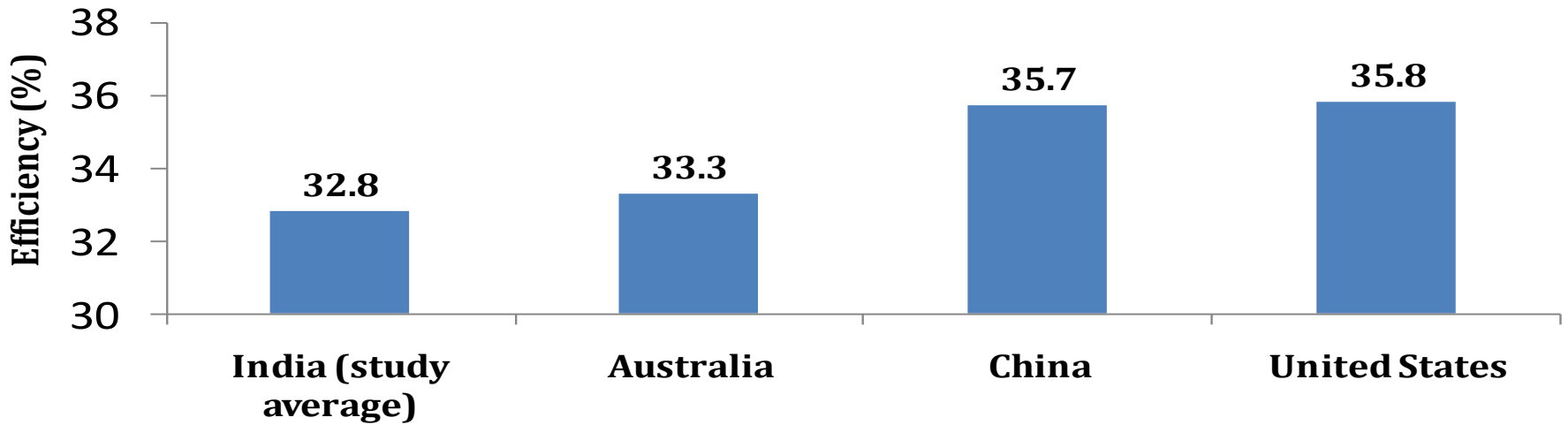
Energy Access



Electricity Consumption per Capita



Energy Efficiency – Very low



- ✓ **Total sub critical capacity - 80%**
- ✓ >300 MW and less than 10 years,
- ✓ 40% units are less than 210MW
- ✓ Quarter of capacity had exceeded life;
- ✓ Half of capacity – efficiency was 10% less than design (poor O&M practices)
- ✓ Inefficient plants have high auxiliary consumption: as high as 15.5%; Best ~6%
- ✓ Fleet PLF around 60%; Availability – average 88%

Air pollution

Loose norms for PM - Almost two thirds of the plants were not in compliance with even these standards.

~ **55% plants** (with norm 150mg/Nm³) - very high emissions

~ **10% plants** (norms 50-75mg/Nm³) - emissions clearly visible

No norms for SO₂, NO_x, Hg: A few states have SO₂ norms;

Inadequate pollution monitoring and reporting regime:

- Quarterly reporting to regulator; quarterly inspection
- Data is frequently unreliable

Ambient Air Quality – Major fugitive dust emission sources are coal handling & storage, and fly ash pond (1 bt on ground, 60 mt added annually)



Fly ash

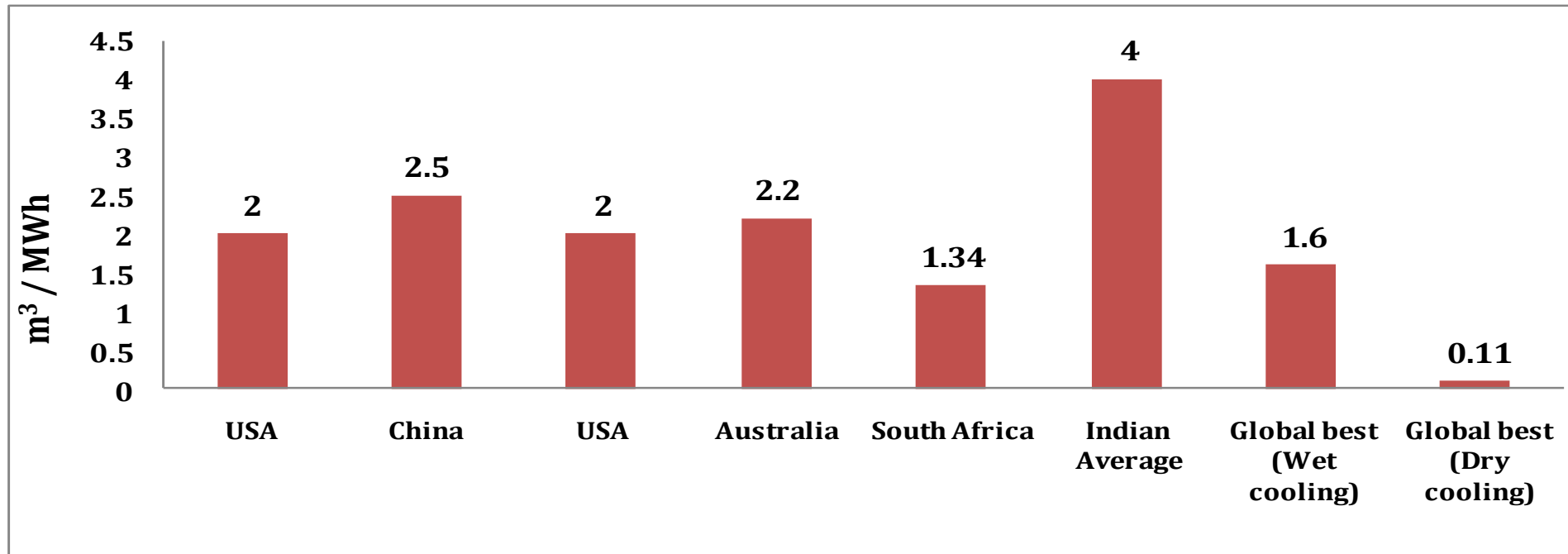
Year	Ash Generation in mt	Ash Utilization in mt	Cement	Bricks	Roads, embankments	Reclamation	Mine filling	Agriculture	Others
2011-12	145.42	85.05	38.08	5.83	11.4	14.21	7.74	0.88	6.91
2012-13	163.56	100.37	41.33	9.98	16.95	11.83	10.34	2.5	7.44
2013-14	172.87	99.62	39.17	12.23	15.3	11.74	11.20	2.88	7.10

- **Use in cement success (~60 %) but growth tapering**
 - One-third not useful - Mine filling/ reclamation etc;
- **Ash disposal** – large land requirement (~45 % of total plant area)
- **Ash Ponds** – most are unlined; almost third leaked into water bodies



Indian plants – water guzzlers

- ✓ Water is cheap in India: CSE study showed clear co-relation -lower the cost/tariff (as low as 20 paisa/m³) higher the use of water
 - India average 4 m³ /MWh – twice that of US, China
 - ~64% for cooling. Number of Indian plants have low COC; significant capacity employs once-thru-cooling,
 - ~21% for ash handling - average 8 m³ water/tonne ash used for handling



Roadmap: Policies announced

- No subcritical plants after 2017
 - Of 72GW under construction around 40 GW is Subcritical
- Old plants totaling 34,000MW to be retired;
 - last 5 years only 3,700 MW closed
- Coal tax: increased from Rs.100 to Rs.400 (\$6) per tonne coal over last 3 years to fund projects under National Clean Environment Fund
- Tighter Air pollution (PM, SOX, NOX) and water use standards; stronger measures to push ash use
- **Implementation challenge**
 - Financing –\$10-12 billion needed; but, power sector already distressed
 - Supplier capacity to meet required scale and 2 year timeline
 - Limited technical and project management skills (power plants)
 - Technology suitability for Indian coal (+40% ash) and new standards
 - Regulatory oversight