Coal Power Generation in India and its Role in Economic Efficiency

Symposium on Sustainable Power Supply Mix in the Future

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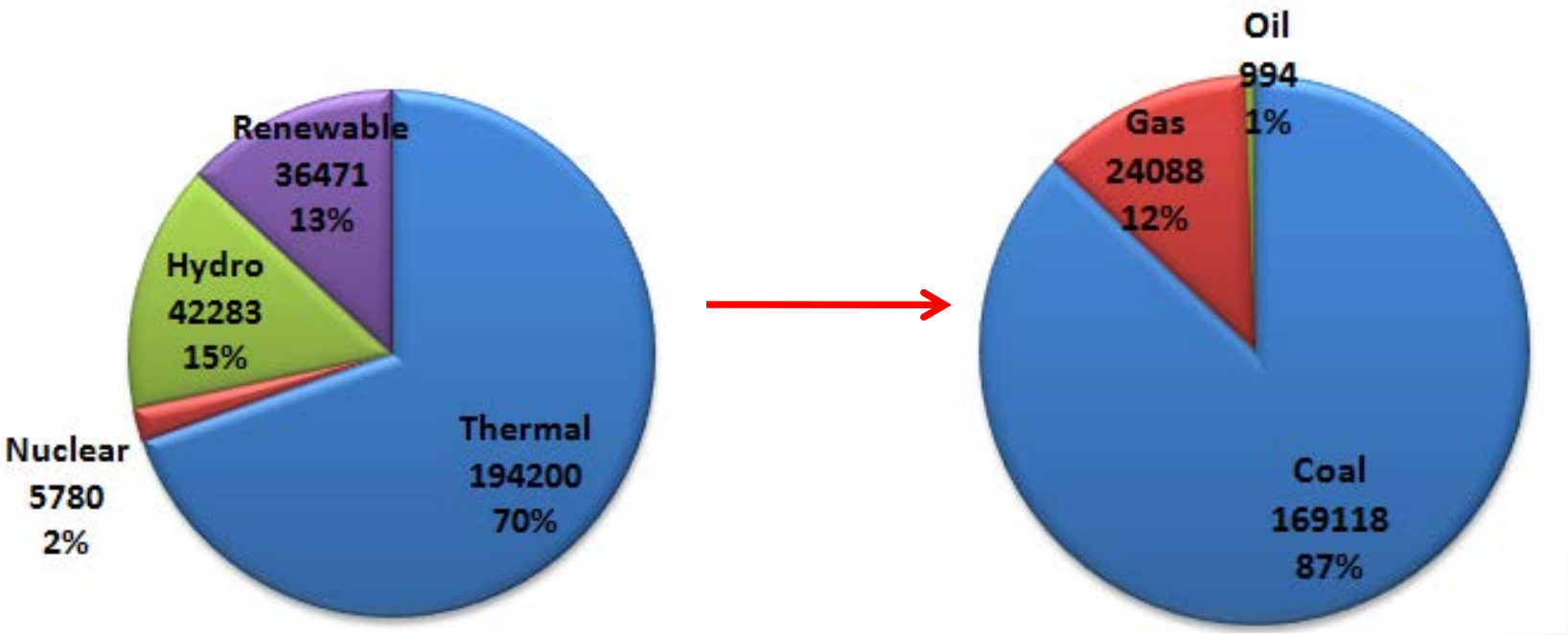
Outline

- Power sector in India
- Coal supply
- Generation technologies

Power sector in India – An overview

Power generation mix in India

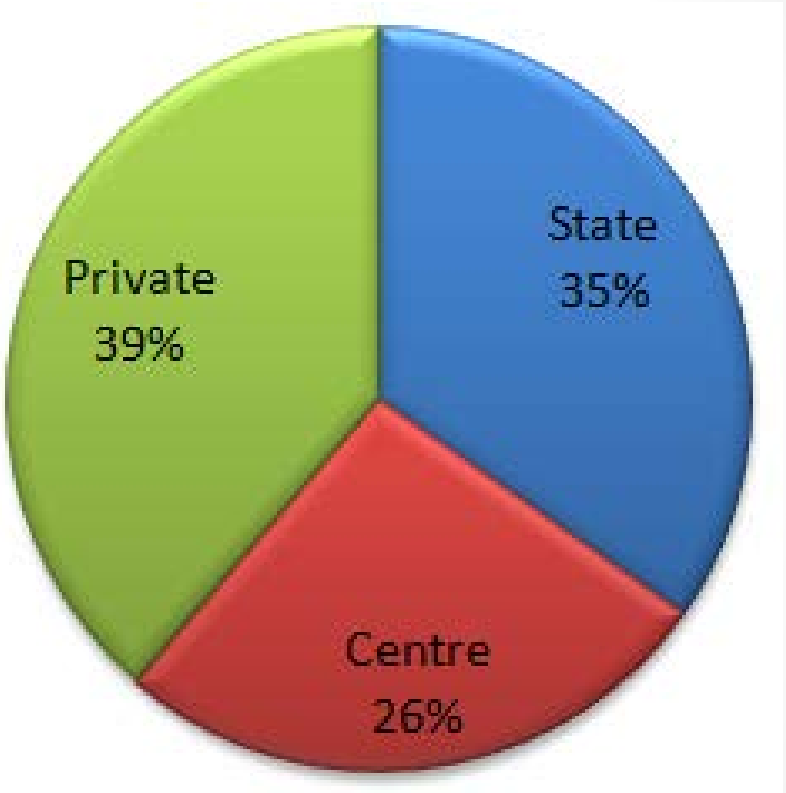
- Thermal based power accounts for 70% of total generation
- Coal accounts for more than 80% of thermal mix



- Per Capita Consumption- 870 kWh/Yr is very low
- Overall deficit 3.6%; Peak deficit 4.7%

Generation capacity

- Installed capacity (2015) : 280,000 MW
- Capacity doubled in 8 years
  - 140,000 MW (2007)
  - Average annual growth rate : 8.5%
- Average capacity addition was 22,000 MW per year in last 4 years



Sector-wise mix

Planned capacity additions till 2017

Thermal 50,000 MW; Hydro 7,200 MW; Nuclear 1,500 MW

NTPC	
Barh (2 X 660 MW)	**1320 MW**
Bongaigaon	**750 MW**
Mauda	**660 MW**
IL&FS Tamil Nadu, Cuddalore	
Phase 1 (2 X 600 MW)	1200 MW
Phase 2 (3 X 800)	2400 MW
Maharashtra State Power Generating Co	
Kordi	1980 MW
Chandrapur	500 MW
Parli	250 MW
Prayagraj Power Generation Co, Bara, UP (3 X 660)	1980 MW
UP Rajya Vidyut Nigam	
Obra (2 X 660)	1320 MW
Anpara Unit II	500 MW
KSK Mahanadi, Akalatara, Chhattisgarh	
Unit III & Unit IV(2 X 600)	1200 MW

Ultra mega power projects (UMPP)

Completed projects

- Tata Power, Mundra, Gujarat (5 X 800 MW) : 4000 MW
- Reliance Power, Sasan, MP (6 X 660) MW) : 3960 MW

Under construction/Awarded

- Reliance Power, Krishnapatnam, AP (5 X 800 MW) : 4000 MW
- Tilaiya (Jharkhand)
- Bidding process for 4 more units will be announced during the financial year

- The Government of India is focusing on setting-up of 16 UMPPs with supercritical parameters
- Installed generation capacities of 4000 MW per unit
- UMPPs are located either in pithead (domestic coal) and coastal (imported coal)

Issues with other planned UMPPs

- Out of 16 proposed UMPPs, each of 4000 MW only 4 were awarded since 2005-06

- Most proposals stalled due to:
  - Delays in land acquisition
  - Policy changes envisaged
    - Coal linkage (assured fuel supply commitments from the government)
    - Swaping of coal among power plants to optimise transportation costs
    - New tariff policies formulated – proposes mandatory bidding process and differential tariffs
    - Bidding norms and coal linkages are being finalised

Coal supply

Domestic production of coal

- Largest energy source; domestic production ~ 570 million tonnes
  - Proven reserves 126 billion tonnes
  - Open casting mining predominant
  - Indian coal has high ash content, variations in calorific value and presence of extraneous matter
- Domestic production not keeping-up with demand due to:
  - Mining constraints (techno-economic viability)
  - Infrastructure bottlenecks
  - Environmental regulations

Coal Quality

- High ash content & low calorific value of coal
- Low sulphur content

Description (Source/Type)	Unit	Design Coal	Worst Coal	Best Coal
Proximate Analysis				
Fixed Carbon	%	26.00	23.00	32.00
Volatile matter	%	19.00	18.00	22.00
Moisture	%	15.00	17.00	12.00
Ash	%	40.00	42.00	34.00
Total	%	100	100	100
HHV	kcal/kg	3300	2800	4000
Ultimate Analysis				
Carbon	%	31.37	28.93	40.08
Hydrogen	%	3.40	2.40	3.50
Sulphur	%	0.40	0.5	0.36
Nitrogen	%	1.5	1.45	1.78
Oxygen(difference)	%	7.75	7.26	8.03
Moisture	%	15.0	17.0	12.0
Ash	%	40.0	42.0	34.0
Carbonates + Phosphorous	%	0.58	0.46	0.25
Hard Grove Index		55	50	60

Coal imports

- Large quantities imported (~ 220 million tonnes)
  - Major imports from Indonesia, South Africa and Australia
  - Only 10-15% imported coal can be in existing boilers
- Projected to increase to 900 million tonnes in 2030

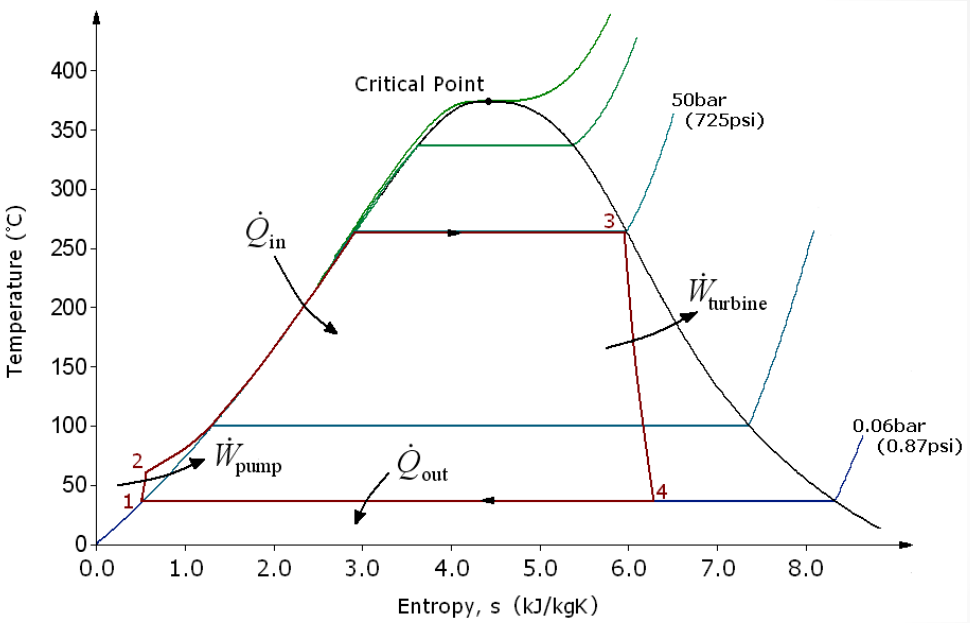
Coal washing

- Washing requires especially before transporting long distances
  - Current capacity 145 million tonnes
- Need for capacity additions
  - No significant increase in recent years
- Need for improvement in washing technologies
  - Problems of wet coal to power plants

Generation technologies

Supercritical Steam Cycle Technology

- More than 600 supercritical coal fired boilers in operation worldwide.
- Prevalent cycle parameters :
  - Pressure – 246 to 250 kg/cm^2
  - Temp - 538 ^{o}C to 600 ^{o}C
- Preferred steam parameters include high steam temp (566 to 593 ^{o}C) depending upon site specific techno economics.
- Increase in pressure and main & reheat temp more than 537 ^{o}C leads to significant improvements in heat rate



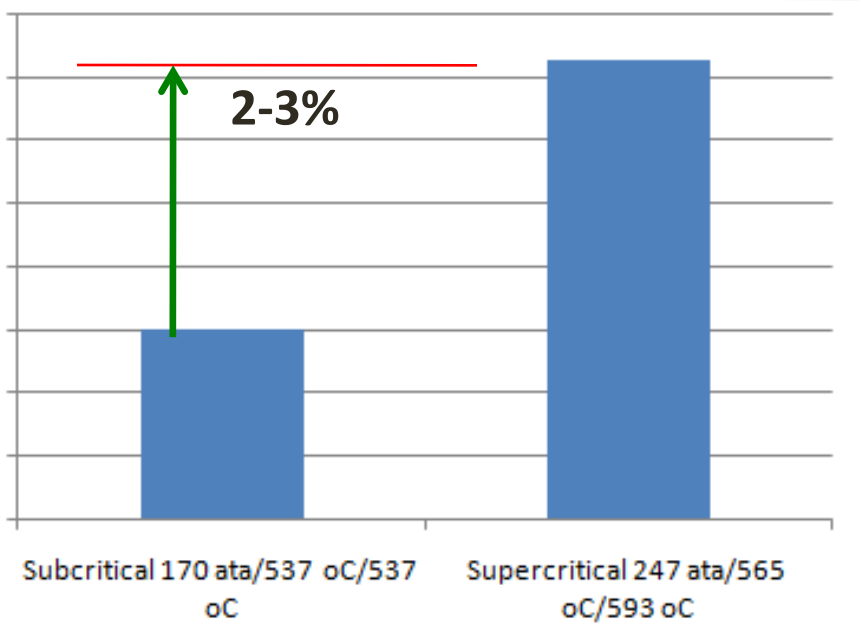
SUPER CRITICAL STEAM PARAMETERS:

PARAMETERS MORE THAN CRITICAL STATE

- **STEAM PRESSURE > 221.2 BAR**
- **STEAM TEMPERATURE > 374.15 Deg C**

Advantages of supercritical steam cycle technology

- Supercritical units have higher plant efficiencies than subcritical units because of higher steam parameters
- Gross plant efficiency of supercritical units are around 40-41% compared to 38% of subcritical based units
- Gross plant efficiency of ultra-supercritical units are around 41-42% (280 ata/593 ^{o}C/593 ^{o}C)
- At international level, Advanced ultra-supercritical units have reached plant efficiencies of 47-49%

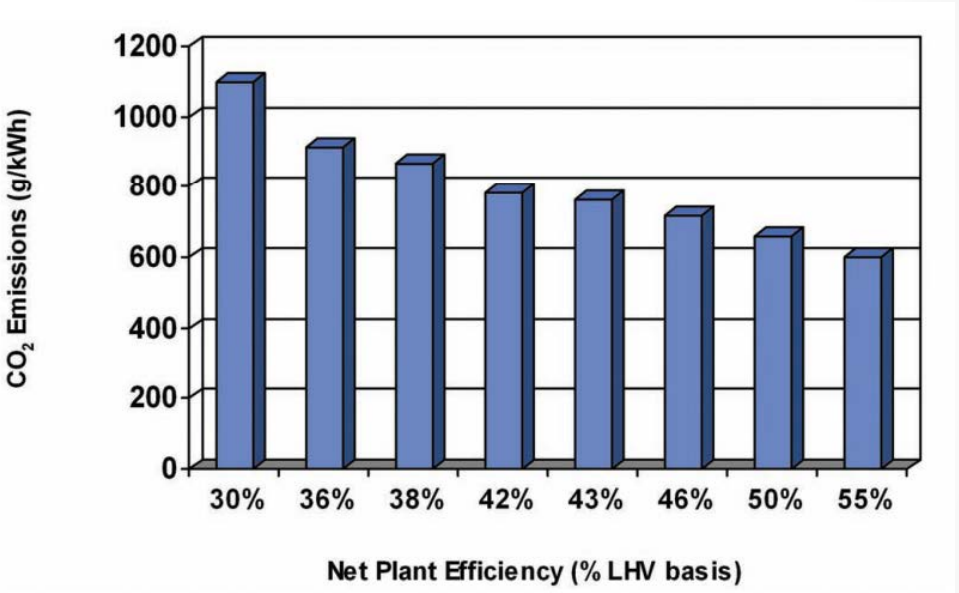


Fuel saving

Reduced fuel costs due to improved plant efficiency

Other advantages

- Significant improvement of environment by reductio in CO_2 emissions
- Plant costs less as compa to other clean coal technologies
- Much reduced NOx, SOx and particulate emissions



Evolution of coal based plants in India

Period	1960s	1970s	1977	1983	Under Constrn.
Unit Size (MW)	60-100	110-120	200-250	500	660-800
Turb Inlet Pressure / Temp	70-90 ata 490-535^{0}C	130 ata 535^{0}C	130 ata 537^{0}C	170ata 537^{0}C	247 ata 537^{0}C
Reheat Temp.	No reheat	535^{0}C	537^{0}C	537^{0}C	565^{0}C
Turbine Cycle Heat rate (kCal/kWh)	2370	2060 to 2190	1965	1945	1900
Gross efficiency (%)	30.5	33 to 35	37.2	37.6	38.5

Future outlook

- Coal will continue to have maximum share towards installed capacity for power generation in India
- Clean Coal Technologies such as supercritical, ultra supercritical and advanced ultra supercritical system will be the focus in future power projects
- 800-1000 MW unit plants more suitable to handle Indian coal but technology cooperation with international manufacturers

Thank you for your attention

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