THE BENGAL CHAMBER

Mitigation Options In Power Generation In India

BY

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PRESENT POWER GENERATION SCENARIO IN INDIA

ALL INDIA REGIONWISE GENERATING INSTALLED CAPACITY (MW) OF POWER UTILITIES INCLUDING ALLOCATED SHARES IN JOINT AND CENTRAL SECTOR UTILITIES

(As on 30-06-2013)

SL. NO.	REGION	THERMAL COAL	GAS	DSL	TOTAL	Nuclear	HYDRO (Renewable)	R.E.S.@ (MNRE)	TOTAL
1.00	Northern	33,073.50	5,031.26	12.99	38,117.75	1,620.00	15,467.75	5,589.25	60,794.75
2.00	Western	50,244.51	8,988.31	17.48	59,250.30	1,840.00	7,447.50	8,986.93	77,524.73
3.00	Southern	25,182.50	4,962.78	939.32	31,084.60	1,320.00	11,353.03	12,251.85	56,009.48
4.00	Eastern	23,727.88	190.00	17.20	23,935.08	0.00	4,113.12	454.91	28,503.11
5.00	N. Eastern	60.00	1,187.50	142.74	1,390.24	0.00	1,242.00	252.68	2,884.92
6.00	Islands	0.00	0.00	70.02	70.02	0.00	0.00	6.10	76.12
7.00	All India	132,288.39	20,359.85	1,199.75	153,847.99	4,780.00	39,623.40	27,541.71	225,793.10

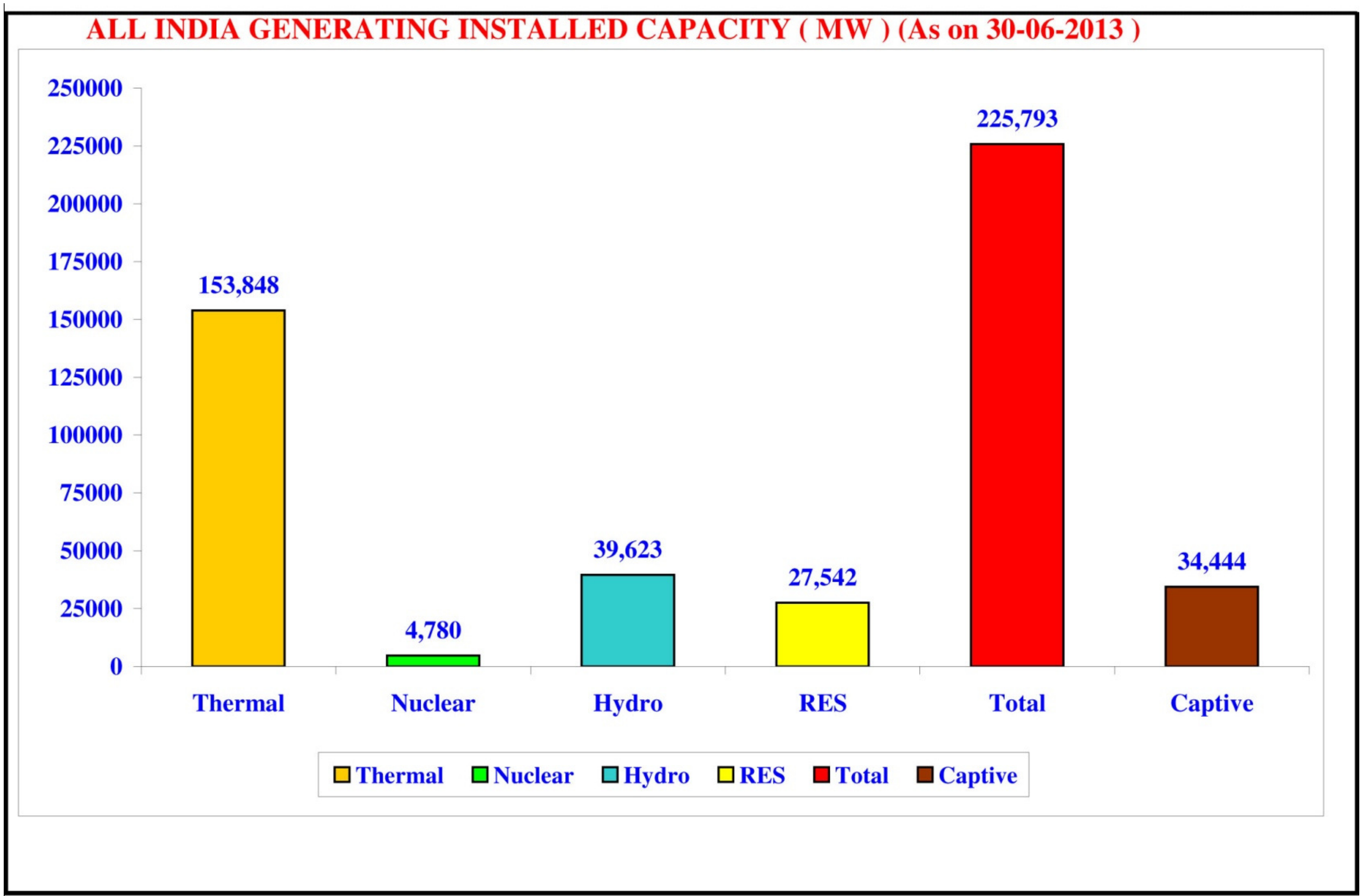
Captive Generation Capcity in Industries having demand of 1 MW or above, Grid interactive(as on 31-03-2011)=34,444.12 MW

@ Renewable Energy Sources (RES) includes Small Hydro Project(SHP),Biomass Power(BP), Urban & Industrial waste Power(U&I), Wind Energy and Solar Power.

Note: **UNITS COMMISSIONED, DERATED & DECOMMISSIONED DURING June'13**

Thermal 1. Tiroda TPP Ph-II Unit 1(660 MW) in Maharashtra commissioned on 10-06-2013 by Adani Power Ltd.

Hydro NIL

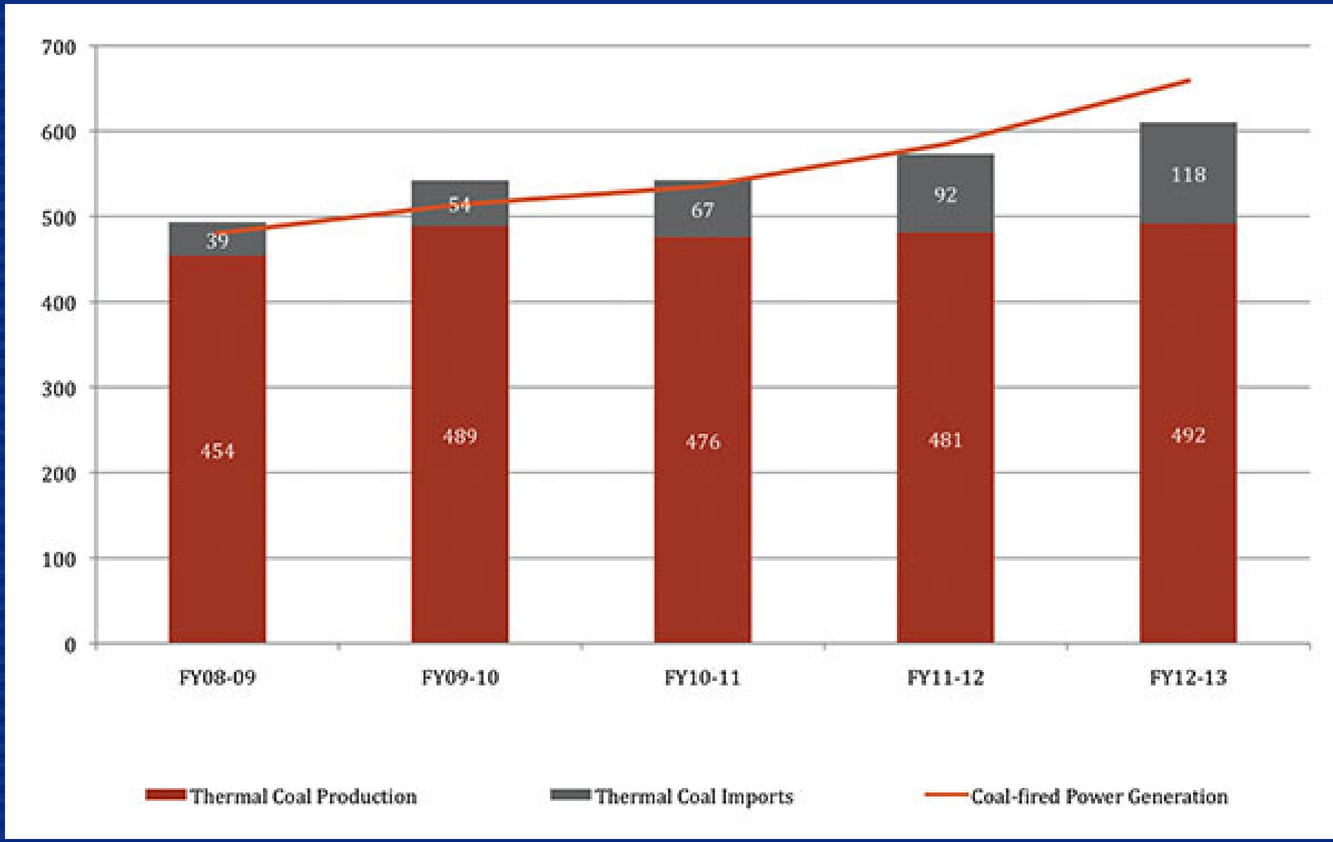


ENERGY SAVED IS ENERGY PRODUCED

POWER DEMAND IN INDIA
(Peak Load in MW)

YEAR	PEAK REQUIREMENT	PEAK AVAILABILITY
2012-13	135,453 MW	123,294 MW
2013-14	144,225 MW(Anticipated)	140,964 MW (Expected)

REQUIREMENT OF COAL FOR POWER SECTOR



Indian Power Generation – (TWh), Coal sourcing – (million t).

COAL RESERVES IN INDIA (in Million Tonnes)

STATES	PROVED	INDICATED	INFERRED	TOTAL
ANDHRA PRADESH	6582.47	3502.36	2935.67	13020.50
ARUNACHAL PRADESH	31.23	11.04	47.96	90.23
ASSAM	228.37	26.83	65.01	320.21
BIHAR	30972.17	28352.38	5880.82	65205.37
MADHYA PRADESH	10097.53	21979.22	8982.84	41059.59
MAHARASHTRA	3524.53	1448.23	1663.24	6636.40
MEGHALAYA	88.99	69.73	300.71	459.43
NAGALAND	3.43	1.35	15.16	19.94
ORISSA	6869.74	22296.83	17553.09	46721.66
UTTAR PRADESH	662.21	400.00	-	1062.21
WEST BENGAL	11382.46	11659.76	4315.91	27358.16
TOTAL	70443.13	89749.76	41760.81	201953.70

CHARACTERISTICS OF INDIAN COAL

	(DRY – ASH - FREE BASIS)
CALORIFIC VALUE	7095-8890 Kcal/kg
VOLATILE MATTER	14% - 45% (1)
ASH CONTENT	12% - 45% (2)
CARBON	76%-93% (3)
SULPHUR	0.2%-1.0% (4)

AIR POLLUTION

- PARTICULATES
- SULPHUR DIOXIDE (SO_2)
- OXIDES OF NITROGEN
- OTHER GASES

WATER POLLUTION

- DEMINERALISATION PLANT EFFLUENT
- BOILER BLOW DOWN
- COOLING TOWER BLOW DOWN
- MISCELLANEOUS SOURCES OF EFFLUENTS
- ASH POND EFFLUENT

LANDUSE

- **THE MAJOR THERMAL POWER PLANTS REQUIRE LARGE AREAS OF LAND TO ACCOMMODATE PLANT,COAL STOCK YARD, COAL HANDLING PLANT,ASH PONDS,SUBSTATION,TOWNSHIPS etc.**
- THE LAND USE CONVERSION BECOMES RELEVANT,IF THE PLANT SITE IS LOCATED ON AGRICULTURAL LAND , FOREST LAND etc
- DURING THE CONSTRUCTION PERIOD, TEMPORARY SETTLEMENTS GROW UP CHANGING THE LANDUSE PATTERN
- THESE SETTLEMENT SHOULD NOT BE PRESENT , AFTER THE CONSTRUCTION PHASE IS OVER

REHABILITATION AND RESETTLEMENT

❖	AS THE THERMAL POWER PLANT REQUIRES A LARGE AREA , 'OUSTEES' CANNOT BE AVOIDED	
❖	REHABILITATION SHOULD BE DONE IN A MANNER THAT WOULD HONOUR THEIR LIFE STYLE,CULTURE, SOCIAL VALUES AND ALSO ENSURE REGULAR MEANS OF INCOME	
❖	NO SINGLE CENTRAL ACT CONCERNING REHABILITATION OF PEOPLE AFFECTED DUE TO LAND ACQUISITION HAS BEEN MADE	
❖	THE PRIME RESPONSIBILITY OF REHABILITATION RESTS WITH THE STATE GOVERNMENT, BUT THE PROJECT PROPONENT NEED TO PLAY AN ACTIVE ROLE IN FORMULATING AND IMPLEMENTING WORKABLE SCHEMES, VIZ	
	▪	PROVIDE THEM ALTERNATE LAND IN THE NEAR VICINITY AS THEY ARE MOSTLY FROM AGRO ECONOMY
	▪	PROVIDING SELF EMPLOYMENT TO THE AFFECTED PERSONS
	▪	JOBS IN THE UNSKILLED CATEGORY
❖	NORMALLY INFRASTRUCTURAL FACILITIES ARE NON EXISTENT IN THE VICINITY AREA. IF PROJECT PROPONENTS PROVIDE THE BASIC AMENITIES TO SOME OF THE VILLAGES , IT WILL HELP TO CREATE CLOSER BOND WITH THE LOCAL PEOPLE	
❖	IN CASE OF LARGE PROJECT OUSTEES A 'REHABILITATTION & RESETTLEMENT ' AND 'COMMUNITY DEVELOPMENT' PROGRAMME IS REQUIRED	

FLY ASH MANAGEMENT

- TODAY IN INDIA , CLOSE TO 100 MILLION TONNES OF FLY ASH IS BEING GENERATED EVERY YEAR AND SO ITS DISPOSAL ASSUMES ONE OF THE MAJOR ENVIRONMENTAL CHALLENGES FACING THE COUNTRY
- MoEF REQUIRES THAT ALL PROPOSED POWER PLANT S SHOULD BE PLANNED WITH A CONCRETE ASH UTILIZATION PROGRAMME WHICH ENTAILS 100% UTILIZATION IN 4 YEARS
- OPTIONS TO MEET THE REQUIREMENT OF MoEF
  - MINE STOWING IS THE ULTIMATE SOLUTION FOR ASH UTILIZATION IN INDIA. THE ENVIRONMENTAL IMPLICATIONS ALONG WITH PRECAUTIONS NEED TO BE ADOPTED FOR SUCH ACTION
  - ALL POWER PLANTS SHOULD BE LINK ED TO A WASHERY WHICH WILL REDUCE 25% ASH GENERATION
  - ANOTHER WAY OF ASH UTILIZATION IS SHORE PROTECTION, SPECIALLY FOR A POWER PROJECT, LOCATED IN CLOSE VICINITY OF A RIVER
  - IT WOULD BE VERY USEFUL FOR PROSPECTIVE ENTREPRENEURS TO MANUFACTURE ASH BASED PRODUCTS AND IF UTILIZATION OF SUCH PRODUCTS ARE MADE MANDATORY BY THE GOVERNMENT FOR SELECTIVE PROJECTS

IMPROVING QUALITY OF COAL INPUTS

THREE ALTERNATIVES TO IMPROVE THE QUALITY OF INDIGENOUS COAL TO INDIAN POWER PLANTS	
❖	IMPROVEMENT IN MINING PRACTICES
❖	BLENDING OF COAL
❖	BENEFICIATION OF COAL

IMPROVEMENT IN MINING PRACTICES

MAJORITY OF COAL DEPOSITS IN INDIA OCCUR WITHIN A DEPTH OF 300 METRES. IN FACT, OF THE TOTAL INDIAN COAL RESERVES OF 202 BILLION TONNES, ABOUT 174 BILLION TONNES LIE WITHIN 600 METRES DEPTH AND 60% OF THIS QUANTUM ARE DEPOSITED WITHIN A DEPTH OF 300 METRES

COAL DEPOSITS WITH DEPTH

TYPE OF COAL	0-300 M BILLION TONNE	301-600 M BILLION TONNE	TOTAL 0-600 M
METALLURGICAL NON – COOKING COAL	14	10	24
- SUPERIOR GRADE	16	8	24
- INTERMEDIATE GRADE	14	5	19
- INTERIOR GRADE SUB TOTAL OF NON-COKING COAL	109	41	150
TOTAL	123	51	174

FOR MAINTAINING A STEADY OUTPUT FROM MECHANISED OPEN CAST MINES, STRICT OPERATIONAL DISCIPLINE NEEDS TO BE FOLLOWED AND DETAILED INFORMATION OF THE TYPE AND GRADE OF COAL DEPOSITS AT VARIOUS DEPTHS AT DIFFERENT MINE FACES BE AVAILABLE

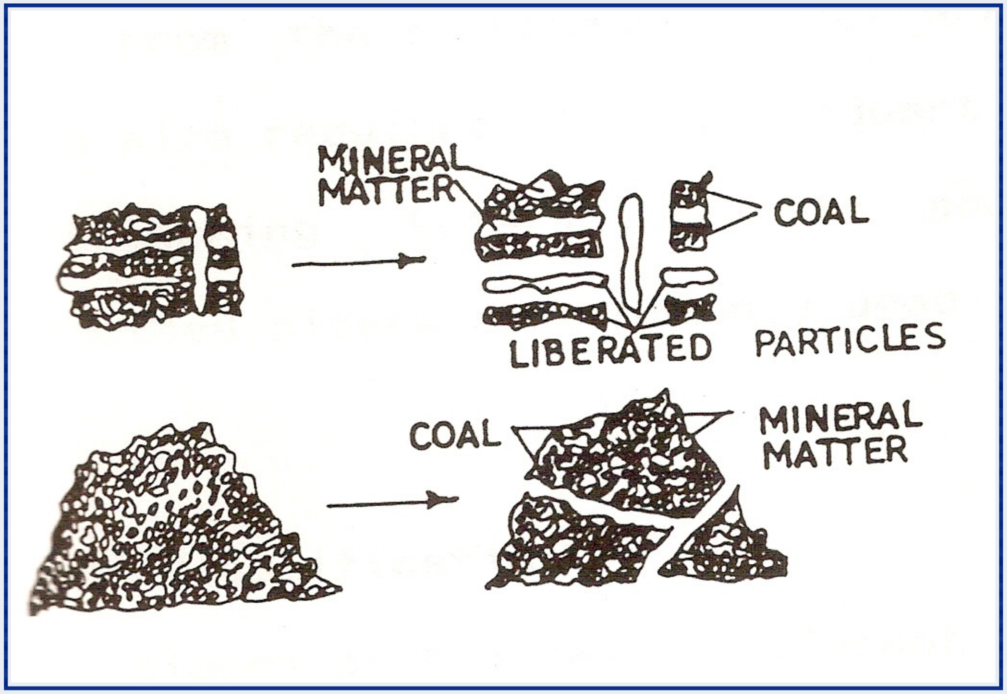
BLENDING OF COAL

- BLENDING OF VARIOUS GRADES/QUALITIES OF RAW COAL AS WELL AS BENEFICIATED COAL HELPS IN ACHIEVING A CONSISTENT INPUT QUALITY TO THE BENEFICATION PLANT OR THE BOILER
- STACKING,BLENDING AND RECLAIMING FACILITIES NEED VERY CAREFUL DESIGN, TAKING INTO CONSIDERATION SUCH FACTORS AS LIABILITY OF THE COAL TO OXIDATION OR SPONTANEOUS COMBUSTION, PRODUCTION RATES AND RELATIVE YIELDS OF VARIOUS PRODUCTS
- SEPARATE STACKING FACILITIES (EITHER AS BINS OR AS STOCK PILES) NEED TO BE PROVIDED BOTH AT THE MINES AS WELL AS THE POWER PLANTS. IT WILL ENSURE A STEADY QUALITY OF FEED INPUT TO THE BOILERS
- STORAGE MAY CAUSES TWO BASIC PROBLEMS, OXIDATION & SPONTANEOUS COMBUSTION. OF THEM THE LATTER IS MORE SERIOUS
- MANY PRECAUTIONARY MEASURES ARE THERE TO MINIMIZE SPONTANEOUS COMBUSTION

BENEFICIATION OF COAL

- **COAL BENEFICATION IS AIMED AT ENSURING A COAL FEED OF CONSISTENT AND OPTIMUM QUALITY**
- COAL BENEFICIATION INVOLVES SEPARATING THE COAL MATERIAL FROM THE MINERAL MATERIALS
- MOST CONVENTIONAL BENEFICATION PROCESSES USE THE DIFFERENCES IN THE RELATIVE DENSITIES OF THE COAL AND MINERAL CONTAMINANTS TO ACHIEVE SEPERATIONS. THE STEPS ARE :
  - SIZE REDUCTION
  - COAL SCREENING AND CLASSIFICATION
  - COAL WASHING
  - CLEAN COAL DEWATERING

DISSEMINATION OF MINERAL MATTER IN COAL AND EFFECT BREAKAGE



DISSEMINATION OF MINERAL MATTER IN COAL AND EFFECT BREAKAGE

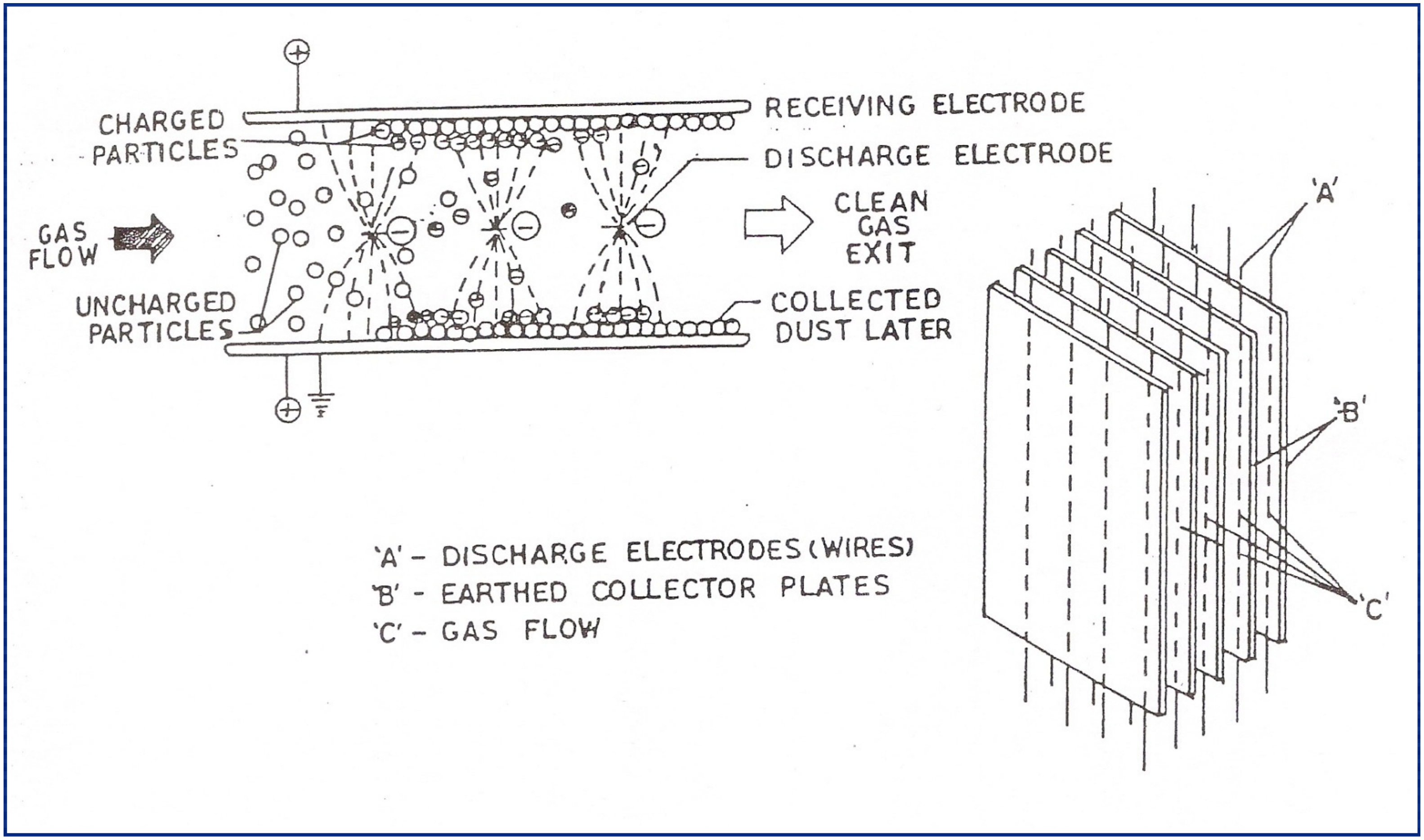
ECONOMIC AND ENVIRONMENTAL ADVANTAGES OF COAL BENEFICATION ARE	
➢	COAL TRANSPORT
➢	COAL STORAGE & HANDLING
➢	COAL PULVERISORS
➢	STEAM GENERATOR
➢	GAS CLEAN UP
➢	SOLID WASTE DISPOSAL

ADD ON TYPE MITIGATIVE OPTIONS

MAIN POLLUTIONAL PROBLEM FROM COAL FIRED POWER PLANTS CENTRES AROUND PARTICULATE AND GASEOUS EMISSIONS FROM THE BOILER STACK. TECHNOLOGIES ADOPTED FOR STACK EMISSION CONTROL FROM COAL FIRED PLANTS ARE:

- **PARTICULATE EMISSION CONTROL**
  - ELECTROSTATIC PRECIPITATORS (ESP)
  - FABRIC FILTERS (FF)
  - VENTURI SCRUBBERS (VS)
- **SO_X EMISSION CONTROL**
  - FUEL SUBSTITUTION
  - COAL BENEFICATION OR WASHING
  - COAL GASIFICATION
- **NO_X EMISSION CONTROL**
  - COMBUSTION MODIFICATION
    - OPTIMISATION OF FIRE SETTINGS (EXCESS AIR,FUEL AND AIR DISTRIBUTION, BURNER SETTINGS)
    - STAGING OF AIR (OVER-FIRE AIR)
    - USE OF SPECIAL LOW NOX BURNERS
    - USE OF SPECIAL REBURN FUEL
    - USE OF FLUE GAS RECIRCULATION
- **CO_2 EMISSION CONTROL**

SCHEMATIC LAYOUT OF PLATE AND WIRE PRECIPITATOR AND DIAGRAM OF BASIC MECHANISMS OPERATING IN PRECIPITATOR



FACTORS AFFECTING THE PRECIPITATOR PERFORMANCE	
❖	ASH CONTENT
❖	ASH RESISTIVITY
❖	PARTICLE SIZE
❖	SNEAKAGE AND RAPPING LOSSES
❖	VOLUMETRIC FLOW
❖	GAS TEMPERATURE

ASH CONTENT

FOR A CERTAIN DESIGN AND SIZE OF THE ESP, THE EMISSIONS VARY WITH INLET DUST LOADING. TYPICALLY ,AN INCREASE IN ASH CONTENT FROM 20%-25% MAY INCREASE THE EMISSION BY ABOUT 40%

ASH RESISTIVITY

DUST LAYER POSSESSES A RESISTANCE, SO THERE MUST BE A VOLTAGE DROP ACROSS IT WHICH HAS AN EFFECT OF REDUCING THE ELECTRIC FIELD WITHIN THE COLLECTING SPACE, THERFORE REDUCING THE COLLECTING EFFICIENCY. ASH RESISTIVITY IS ALSO SENSITIVE TO TEMPERATURE. HIGH TEMPERATURE PRECIPITATORS ARE DESIGNED TO BENEFIT FROM THE LOWER RESISTIVITY OF PARTICULAR ASHES AT HIGH TEMPERATURE

PARTICLE SIZE

THE COLLECTION STORE ON A PARTICLE INCREASES AS THE PARTICLE DIAMETER INCREASES. PRECIPITATORS THEREFORE WORK BEST WITH THE LARGER FRACTION OF FLY ASH. IF THE MEAN FLY ASH SIZE IS DECREASED BY A CHANGE IN COAL TYPE, THE PERFORMANCE OF THE PARTICIPATOR WILL DROP, ALL OTHER FACTORS REMAINING UNCHANGED.

SNEAKAGE AND RAPPING LOSSES

	DUST THAT PASS THROUGH THE CLEARANCE BETWEEN THE ELECTRODES AND CASING IS KNOWN AS SNEAKAGE LOSS WHICH MEASURES UPTO 7% OVER EACH STAGE
	DUST RELEASED IN THE FRONT STAGES OF THE ESPs BY RAPPING IS USUALLY COLLECTED IN THE FINAL STAGES. HOWEVER THE DUST RE-ENTRAINED IN THE FINAL STAGE IS LOST. THIS LOSS IS 12% OF THE DUST COLLECTED IN THE FINAL STAGE

VOLUMETRIC FLOW

INCREASE IN FLOW RATE REDUCES THE TIME REQUIRED FOR PARTICLES TO BE COLLECTED . THIS RESULTS IN A REDUCTION IN COLLECTION EFFICIENCY e.g. A 20% INCREASE IN FLOW MAY INCREASE EMISSION BY ABOUT 50%.

GAS TEMPERATURE

ALTHOUGH NOT A PRIMARY PARAMETER, GAS TEMPERATURE IS IMPORTANT AS IT STRONGLY AFFECTS BOTH THE GAS FLOW RATE AND THE RESISTIVITY OF THE DUST. AS TEMPERATURE RISES, THE VOLUMETRIC FLOW RATE INCREASES DUE TO GAS EXPANSION. ALSO THE RESISTIVITY OF THE DUST INCREASES TO A CERTAIN LEVEL AND THEN DECREASES. IN GENERAL, PRECIPITATOR EFFICIENCY IMPROVES WITH DECREASE OF GAS TEMPERATURE

MODERN TRENDS IN ESP TECHNOLOGY

MODERN TRENDS IN ESP DESIGN INCLUDE USE OF PULSE ENERGISER, LARGER VOLTAGE DISTANCE, OPTIMISATION OF VOLTAGE ACROSS EACH ZONE.PULSE ENERGISER HAS BEEN FOUND THE MOST EFFECTIVE . PULSE ENERGISER WORKS ON PRINCIPAL THAT BETTER IONISATION IS ACHIEVED WHEN THE VOLTAGE IS PASSED IN PULSES AS AGAINST A STEADY LEVEL. ANOTHER MAJOR ADVANTAGE IS THAT IT CAN BE EASILY RETROFITTED IN AN EXISTING ESP. ESPs OPERATING AT LOWER TEMPERATURES OF 130-150^{0}C ARE CURRENTLY GAINING POPULARITY

FABRIC FILTERS

- FABRIC FILTER IS USED FOR GAS CLEANING IN THE PROCESS INDUSTRY.
- THE NEED TO IMPROVE COLLECTION EFFICIENCY COUPLED WITH THE DEVELOPMENT OF NEW FIBRES HAS RESULTED IN THE ECONOMIC APPLICATION OF FIBRE FILTERS IN POWER PLANT
- FIBRE FILTERS HAVE COLLECTION EFFICIENCIES EXCEEDING 99.9% AND PROVIDE IMPROVED CAPTURE OF SUBMICRON PARTICLES AS COMPARED TO ELECTROSTATIC PRECIPITATORS
  - PULSE JET CLEANED FILTERS
  - SHAKER CLEANED FILTERS
  - REVERSE FLOW CLEANED FILTERS

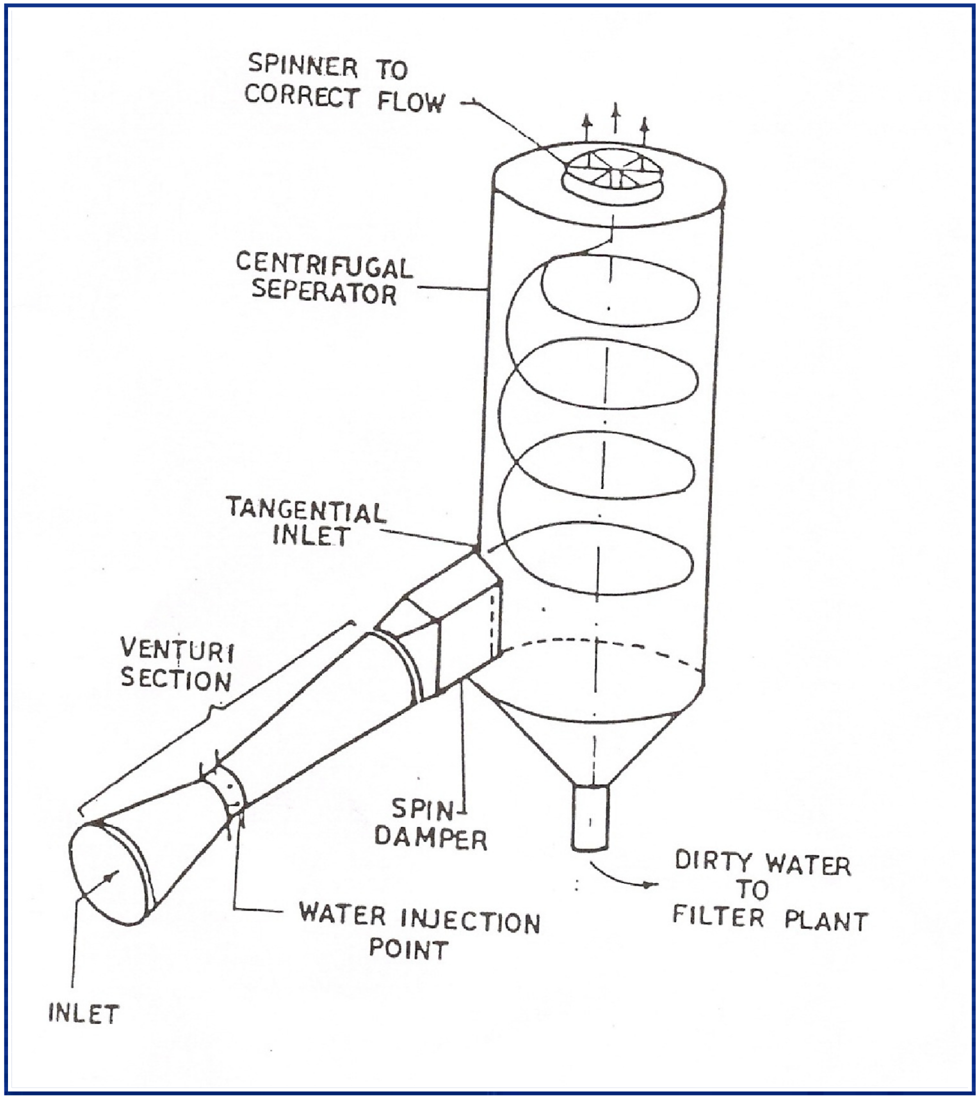
PROPERTIES OF FIBRES TRILLED FOR FABRIC FILTERS

FIBRE TYPE	POLYESTER	COPOLYMER ACRYLIC	HOMO POLYMER ACRYLIC	POLY PHENYLENE SULPHIDE	GLASS
TRADE NAME	DACRON	ORLON	DRAYLON T	RYTON	HYGLASS
MAXIMUM CONTINUOUS TEMP	130 ^{0}C	120 ^{0}C	130 ^{0}C	190 ^{0}C	260 ^{0}C
ACID RESISTANCE	FAIR	GOOD	VERY GOOD	EXCELLENT	EXCELLENT
RELATIVE COSTS	1	1.3	1.5	7	7
INDUSTRY	SHORT LIFE DUE TO ACID ATTACK	FAILED DUE TO TEMP. EXCURSIONS	WIDE SPREAD USE	PERFORMS WELL IN PILOT PLANT BUT EXPENSIVE	LIMITED TO HIGH TEMP DUTY

PERCENTAGE OF SELECTED TRACE ELEMENTS PASSING THROUGH FABRIC FILTERS & ESPs

	FABRIC FILTER	ESP
ARSENIC	0.23	3.33
MERCURY	1.80	2.00
CADMIUM	0.35	1.15
LEAD	1.05	1.87
ANTIMONY	0.12	2.43

VENTURI SCRUBBER



COMPARATIVE ASSESMENT OF ESP, FABRIC FILTER & VENTURI SCRUBBER

ELECTROSTATIC PRECIPITATOR	FABRIC FILTER	VENTURI SCRUBBER
Dry collection	Dry collection	Wet collection
Very high efficiency at high capital cost	Very high efficiency at high capital cost	High efficiency at moderately high capital cost
Difficulties with explosive & inflammable parameters	Same as ESP	Very well adopted for such conditions
Hygroscopic & wet dust – suitable to an extent	Not very suitable	Suitable
Electrical resistivity dependent	Independent	Independent
Efficiency depends on inlet load concentration	Almost independent of inlet load concentration	Dependent on inlet load concentration
High inlet temp & pressure – suitable to an extent	Not very suitable	Suitable
No sludge handling	No sludge handling	Major cost in disposal of sludge & water treatment plant
Pressure control – not required	Not required	Adjustable Venturi cost implications
No absorption	No absorption	Absorption of gas & some trace elements
No chemical corrosion	No chemical corrosion	Problems of chemical corrosion

SO_X EMISSION CONTROL

⌘	TWO BASIC STRATEGIES EXIST FOR CONTROL OF SO_X EMISSION	
⌘	'AT SOURCE' CONTROL STRATEGIES ACT TO PREVENT THE FORMATION OF SO_X IN THE COMBUSTION PROCESS TO PREVENT SULPHUR FROM ENTERING THE COMBUSTION CHAMBER	
⌘	THREE PRIMARY SO_X CONTROL PROCESSES ARE	
	❖	FUEL SUBSTITUTION
	❖	COAL BENEFICATION OR WASHING
	❖	COAL GASIFICATION
⌘	'ADD-ON' MEASURES ARE AIMED TO REMOVE THE SULPHUR COMPOUND FROM THE FLUE GAS AFTER THEY ARE FORMED, KNOWN AS FLUE GAS DESULPHURISATION (FGD)	
⌘	FLUE GAS DESULPHURISATION CAN BE CLASSIFIED AS	
	❖	WET FGD USING LIME OR LIMESTONE
	❖	SPRAY DRY SYSTEMS USING LIMESTONE
	❖	DRY DUCT INJECTION SYSTEMS
	❖	OTHER SYSTEMS

POWER GENERATION CAPACITY	STACK-HEIGHT (metres)
500 MW AND MORE	275
200/210 MW AND ABOVE TO LESS 500 MW	220
LESS THAN 200/210 MW	$H=14\ Q^{0.3}$, where Q is emission rate of SO_2 in kg/hour

IN NO CASE, SHOULD THE STACK HEIGHT BE LESS THAN 30 METRES

NO_X EMISSION CONTROL

BROAD STRATEGIES ARE AVAILABLE FOR NO_X CONTROL		
⦿	PRIMARY CONTROL MEASURES ACT TO PREVENT THE FORMATION OF NO_X IN THE COMBUSTION PROCESS	
⦿	PRIMARY CONTROL MEASURES ARE USUALLY AIMED AT ACHIEVING	
	•	REDUCED AVAILABILLITY OF OXYGEN FOR REACTION WITH VOLATILE NITROGEN SPECIES
	•	REDUCED TEMPERATURE IN THE FLAME
	•	REDUCTION OF ALREADY FORMED NOX THROUGH REACTION WITH HYDROCARBON RADICALS
⦿	SECONDARY CONTROL MEASURES ARE DESIGNED TO REMOVE NOX ALREADY FORMED FROM THE FLUE GAS PRIOR TO ITS RELEASE TO THE ATMOSPHERE	
	•	OPTIMISATION OF FIRING SETTINGS (EXCESS AIR, FUEL AND AIR COMBUSTION, BURNER SETTINGS)
	•	STAGING OF AIR (OVER-FIRE AIR)
	•	USE OF SPECIAL LOW NO_X BURNERS
	•	USE OF SPECIAL RE-BURN FUEL
	•	USE OF FLUE GAS CIRCULATION

REDUCTION IN NO_X EMISSIONS THROUGH COMBUSTION MODIFICATION

NO_X CONTROL MEASURES	NO_X EMISSIONS	NO_X REDUCTION
BASE - NO MODIFICATION	550 -800 ppm	-
LOW EXCESS AIR	450-650 ppm	15-20%
LOW EXCESS AIR + OVER-FIRE AIR	300-500 ppm	35-45%
LOW EXCESS AIR + OVER-FIRE AIR + FLUE GAS RECIRCULATION	200-400 ppm	50-60%
LOW EXCESS AIR + OVER-FIRE AIR + LOW NOX BURNERS + FLUE GAS RECIRCULATION	150-300 ppm	60-70%

CO_2 EMISSION CONTROL

THE EMISSION OF GREENHOUSE GASES AS CO2 IS ANOTHER FORM OF AIR POLLUTION RESULTING FROM THE OPERATION OF THERMAL POWER PLANTS. IN THIS REGARD, IT IS ESTABLISHED THAT PULVERISED COAL COMBUSTION WITH SUPERCRITICAL STEAM CYCLE SIGNIFICANTLY REDUCE CO2 EMISSION. THIS IS A MAJOR BENEFIT OF THIS PROCESS

CLEAN COAL TECHNOLOGIES

CLEAN COAL TECHNOLOGIES CAN BE INSTALLED AT ANY OF THREE STAGES IN THE FUEL CHAIN OR IN A FOURTH MANNER	
■	PRECOMBUSTION – SULPHUR (INORGANIC FORM) AND OTHER IMPURITIES IN COAL ARE REMOVED BEFORE THE COAL REACHES THE BOILER THROUGH WASHING OF COAL
■	COMBUSTION – POLLUTANTS INSIDE THE COMBUSTOR OR BOILER ARE REMOVED WHILE THE COAL BURNS
■	POST-COMBUSTION – FLUE GASES RELEASED FROM COAL BOILERS ARE CLEANED IN THE DUCTWORK LEADING TO THE STACK OR IN ADVANCED VERSIONS OF TODAY'S SCRUBBERS
■	CONVERSION – THE COMBUSTION PROCESS IS BYPASSED ALTOGETHER, AND COAL IS CHANGED INTO A GAS OR LIQUID THAT CAN BE CLEANED AND USED AS FUEL

COMBUSTION CLEANING

CONSIDERABLE RESEARCH WAS CARRIED OUT IN 1960s AND 1970s TO DEVELOP TECHNOLOGIES THAT WOULD ALLOW FOR MORE EFFECTIVE AND ECONOMICAL COAL COMBUSTION. THE PRINCIPAL NEW TECHNOLOGIES WERE BASED ON FLUIDISED BED COMBUSTION	
FLUIDISED BED COMBUSTORS	
❖	BUBBLING FLUIDISED BED COMBUSTORS
❖	CIRCULATING FLUIDISED BED COMBUSTION BOILERS
❖	PRESSURISED FLUIDISED BED COMBUSTORS

INTEGRATED GASIFICATION COMBINED CYCLE POWER PLANT

THE MOST WIDELY USED COAL GASIFICATION SCHEMES ARE	
➢	GASIFICATION OF A LUMP COAL IN A FIXED BED
➢	GASIFICATION OF FINE FUEL IN A FLUIDIZED BED
➢	ENTRAINED-FLOW DUST COAL GASIFICATION

COST OF NO_X EMISSION CONTROL

NO_X CONTROL TECHNOLOGY	CAPITAL COST ($/kWe)	LEVELISED COST ($/t NO_X REMOVED)
LOW EXCESS AIR	1.5	60
OVER-FIRE AIR PORTS	10-40	400
LOW NO_X BURNERS	10-30	200-700
FUEL STAGING (Re – burning)	30-50	200-2000
SELECTIVE CATALYTIC REDUCTION	70-90	1500-3500
SELECTIVE NON-CATALYTIC REDUCTION	10-30	500-1500

COST OF SO_X EMISSION CONTROL

SULPHUR CONTROL TECHNOLOGY	CAPITAL COST ($/kWe)	LEVELISED COST ($/t SO_X REMOVED)
COAL SUBSTITUTION	25-100	DEPENDS ON COAL COST
COAL WASHING	-	150-700
WET FGD- LIME STONE	200-300	300-500
SPRAY DRY SCRUBBER	100-200	400-700
DRY IN DUCT INJECTION	50-150	600-800

COST COMPARISON OF DIFFERENT CLEAN COAL TECHNOLOGIES

	CFBC	PC WITH FGD/SCR	IGCC
CYCLE EFFICIENCY (%)	34.6	36.7	41-42
RELATIVE CAPITAL COST PER KW	1	1.03-1.19	1.15-1.42
RELATIVE O & M COST PER kwh	1	1.49	0.8-0.98

ENVIRONMENTAL PERFORMANCE OF SUPPLEMENTARY MITIGATION OPTIONS

MITIGATION OPTIONS	CO_2	SO_2	NO_X	PM	ASH	WATER	LAND	CAPITAL COST ($/KW)
IMPROVED MINING PRACTICES	1	1	0	0	2	1	2	-
BENEFICIATION	1	2	1	1	2	1	1	75-100
BLENDING	1	2	1	1	1	0	0	1.0
PLANT MANAGEMENT	1	1	1	1	0	2	0	-

ENVIRONMENTAL PERFORMANCE OF PRINCIPAL MITIGATION OPTIONS

MITIGATION OPTIONS	CO_2	SO_2	NO_X	PM	ASH	WATER	LAND
PF COMBUSTION	0	1	0	0	0	0	0
PF + SUPER CRITICAL STEAM CYCLE	2	1	1	1	1	1	0
AFBC/CFBC	1	2	2	1	0	0	0
PFBC	2	2	2	1	0	0	1
IGCC	3	3	3	3	2	2	0
PARTICULATE REMOVAL							
ESP	0	0	0	3	0	0	0
FF	0	0	0	3	0	0	0
VS	0	0	0	2	0	0	0
SO_2 REMOVAL							
WET FGD	0	3	0	1	0	0	0
SPRAY DRY	0	2	0	1	0	0	0
OTHERS	0	2	0	0	0	0	0
NOX REDUCTIONS							
LOW EXCESS AIR	0	0	1	0	0	0	0
OVER FIRE AIR	0	0	1	0	0	0	0
LOW NOX BURNER	0	0	1	0	0	0	0
FUEL STAGING	0	0	1	0	0	0	0
SCR	0	0	3	0	0	0	0
SNCR	0	0	1	0	0	0	0

ENVIRONMENTAL PERFORMANCE AND COST OF PRINCIPAL MITIGATION OPTIONS

	EFFICIENCY	PERCENTAGE REDUCTION IN				COST ($/KW)
		CO_2	SO_2	NO_X	PARTI-CULATES	
PF COMBUSTION	35					
POLLUTION CONTROL SYSTEM						
ESP					99.9	35-45
FF					99.9	-
WET FGD			95			200-300
SPRAY DRY			70-99			100-200
DRY DUCT INJECTION			50-70			50-150
LOW EXCESS AIR				15-20		1.5
LOW EXCESS AIR + OVERFIRE AIR				35-45		10-40
LOW EXCESS AIR + OVERFIRE AIR + LOW NO_X BURNERS				60-70		20-70
SCR				80-90		70-90
SNCR				30-50		10-30

ENVIRONMENTAL PERFORMANCE AND COST OF DIFFERENT TECHNOL0GIES

INDIAN PERSPECTIVE	EFFICIENCY (% LHV)	CO_2 (gc /KWH)	SO_2 (g/KWH)	NOX (g/KWH)	PARTI-CULATES (g/KWH)	COST ($/KW)
PF COMBUSTION (500MW)	35	220	4.2-4.4	3.0-3.2	0.5-0.6	1150-1400
POLLUTION CONTROL						
PARTICULATE CONTROL (ESP)						**35-40**
SO2/NOX CONTROL (275 m STACK)						**9-11**
TOTAL ENVIRONMENTAL MITIGATION COSTS						**100-120**
INTERNATIONAL PERSPECTIVE						
PF COMBUSTION	36-38					**1000-1250**
PF + SUPER CRITICAL SYSTEM CYCLE*	40-44					**950-1150**
AFBC/CFBC	38					**1175-1450**
PFBC	42-45					**1175-1450**
IGCC	43-44					**1525-1875**

THANK YOU