



5TH NATIONAL POWER-GEN ENERGY EFFICIENCY

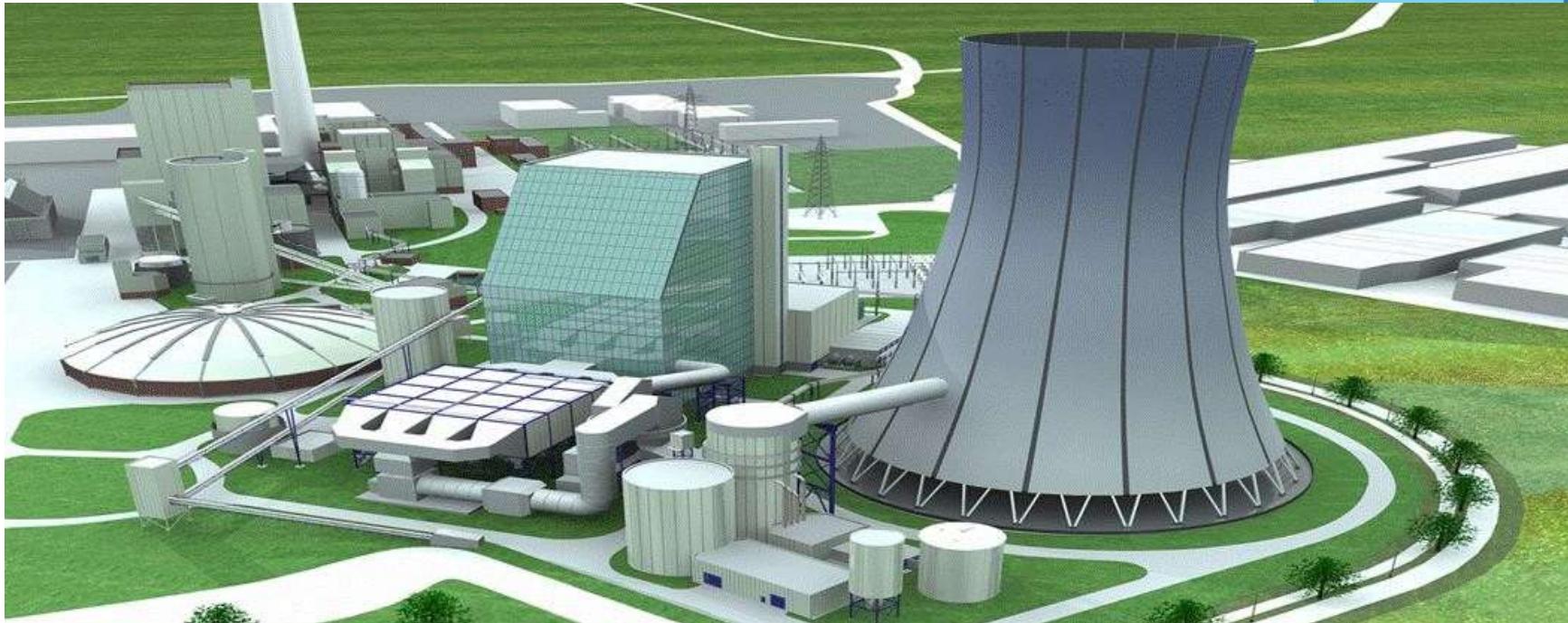
SUMMIT AND AWARDS 2025

Enhancing Efficiency in Indian Thermal Power Plants

**LIFE EXTENSION OF OLD THERMAL PLANTS WITH
ENERGY EFFICIENT CLEAN COAL TECHNOLOGY
RETROFITS AND REDUCTION OF CO2 FOOTPRINT**

MR. SARAJIT SEN

MR. PRABHAT VERMA

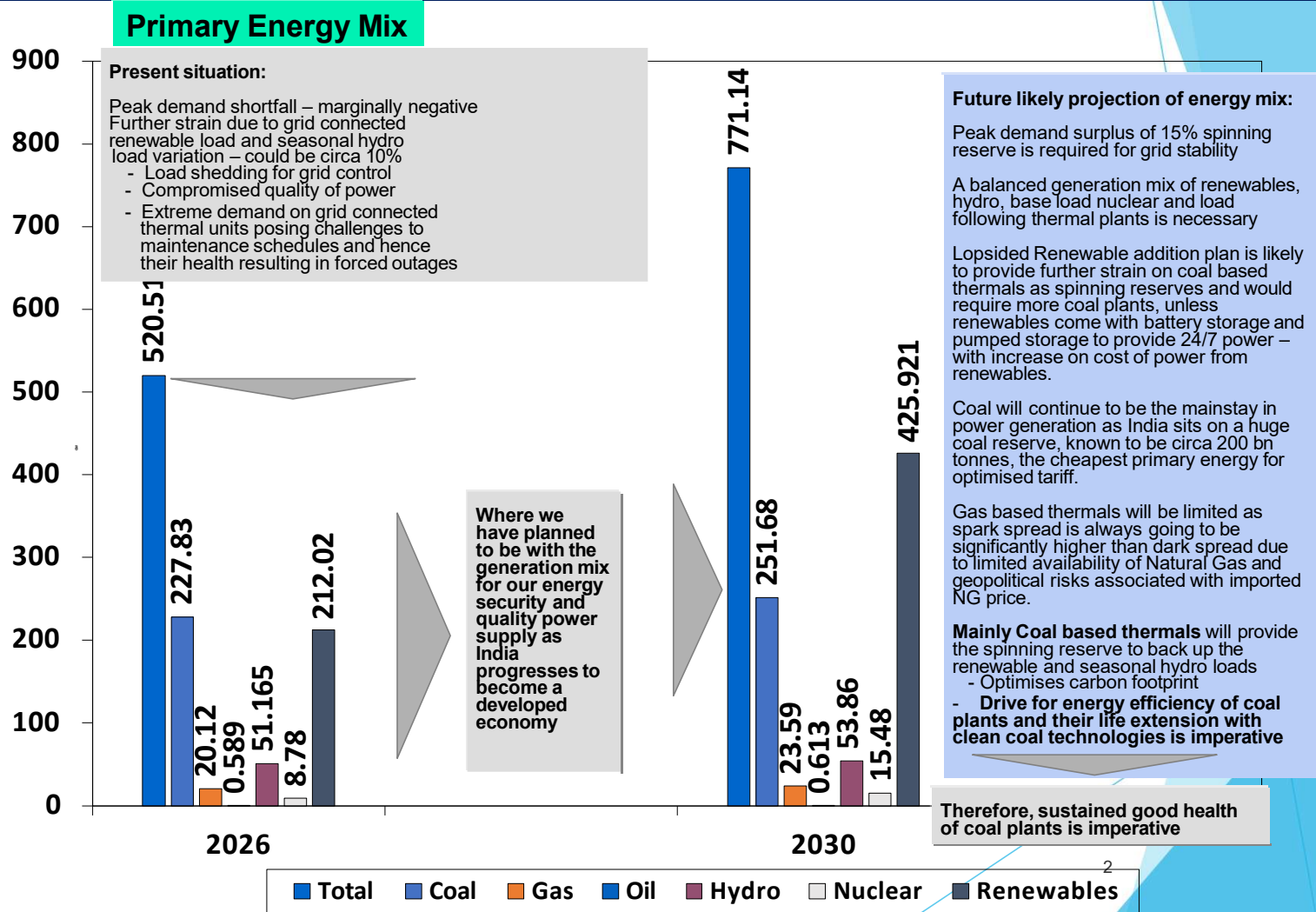


Life Extension of Old Thermal Plants with Energy Efficient Clean Coal Technology Retrofits and reduction of CO₂ footprint

SMARTLùth Solution and Service Private Limited

503, ECO CENTRE, SEC V,
Salt Lake City
Kolkata, 700091
Mobile: +91 98746 43765

Primary Energy Mix Forecast and role of Coal based plants in India

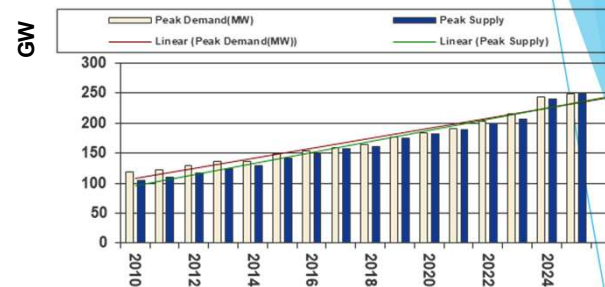


Data: Courtesy CEA

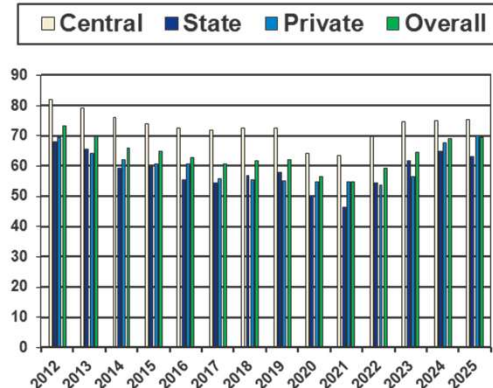
Policy Implementation and Power Sector Performance

- Capacity addition shortfalls
- Supply and Peak Demand is converging but still lacking reserve margin
- Grid connected Renewables add to generation complexities

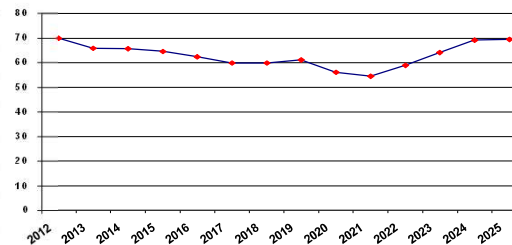
Peak Supply and Demand trend



PLF of Generating Stations



Avg PLF



- Poor Performance of old plants adds to pressures on available generation capacity
- Low PLF, availability, reliability issues
- State Govt. utilities in general are poor performers

Replacement of old inefficient capacity not an option

- puts additional pressure to already stretched new installation plan
- constraints of new permitting, fuel linkage etc
- higher capex and longer gestation time.

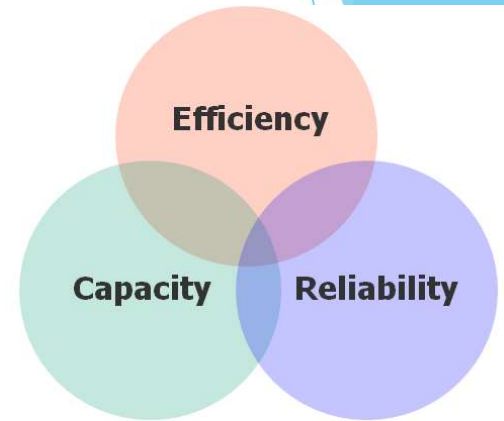
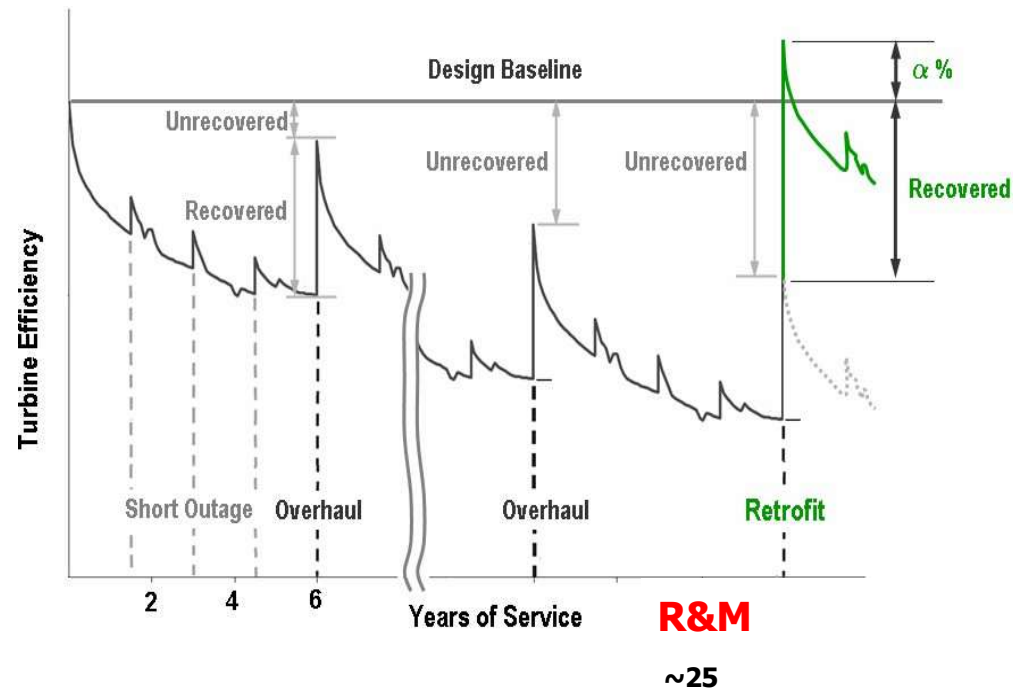
Energy Efficient Plant Life Extension Option is a no-brainer in the present context

- no new plant permits required, lower capex and shorter gestation time
- energy efficiency enhancement significantly improves merit order rating and hence generation economics and ROI
- meets environmental trends
- enhanced reliability, availability improves PLF and hence available power

R&M offers fast, efficient and cost-effective means to increase capacity and its reliability

Data: Courtesy CEA

Plant Cycle Efficiency Enhancement (Unit Heat Rate) - Renovation, Modernisation & Life Extension Objective

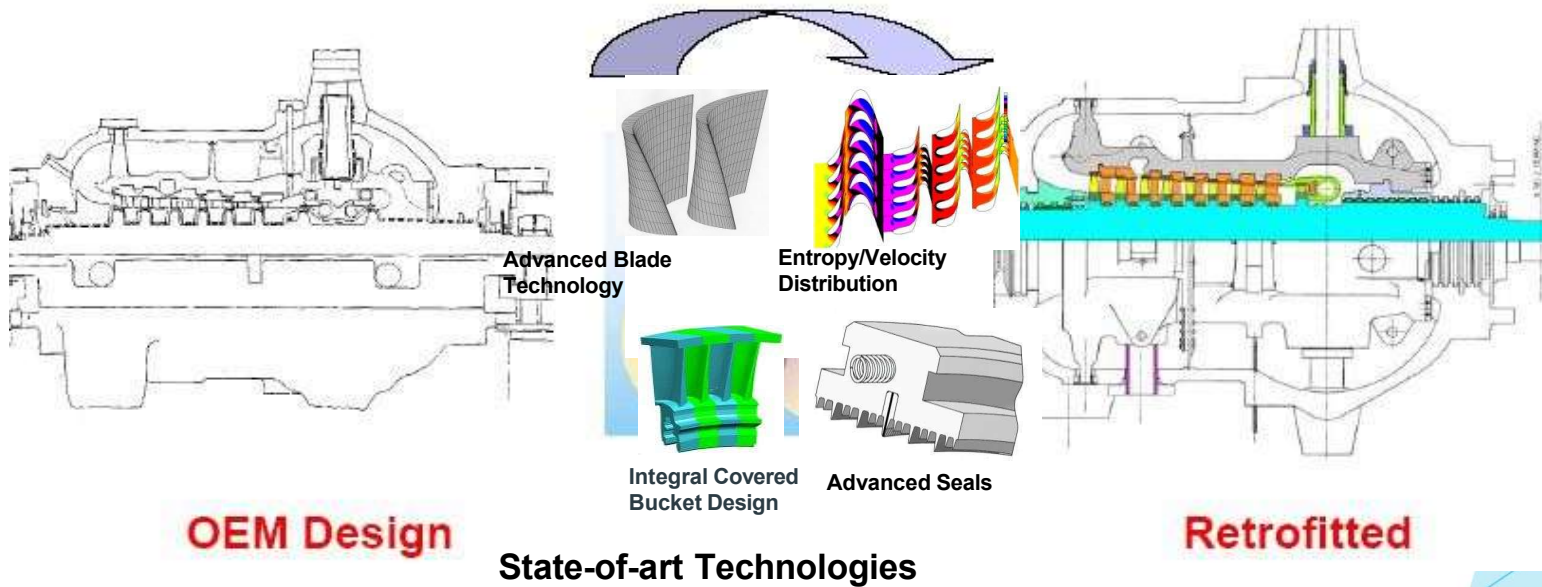


- Enhance Efficiency
- Improved Merit Order for dispatch improves PLF
- Increase Capacity
- Improve Reliability
- Life Extension

Old Plants get a lease of life of at least 15 - 20 years

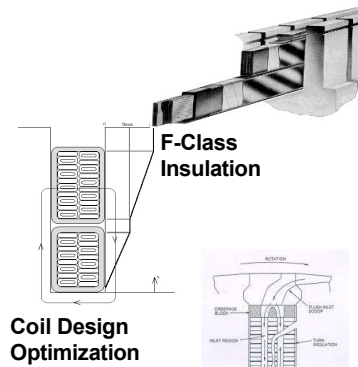
- Higher cycle efficiency results in lower generation costs
- Lower fuel consumption and hence lower carbon footprint
- Lower emissions

Increased efficiency & capacities with quick pay back

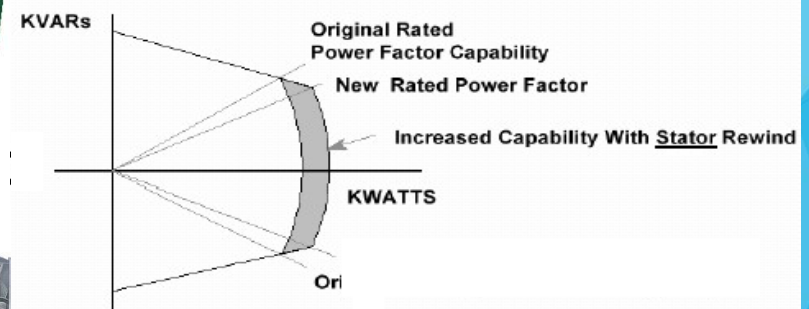
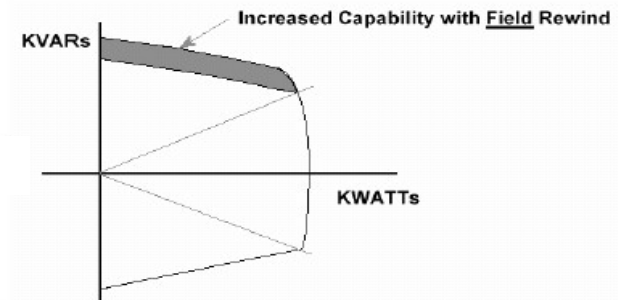
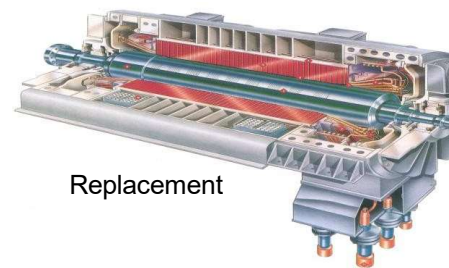


Advanced Technologies - Generator Rehabilitation / Upgrade R&M Option

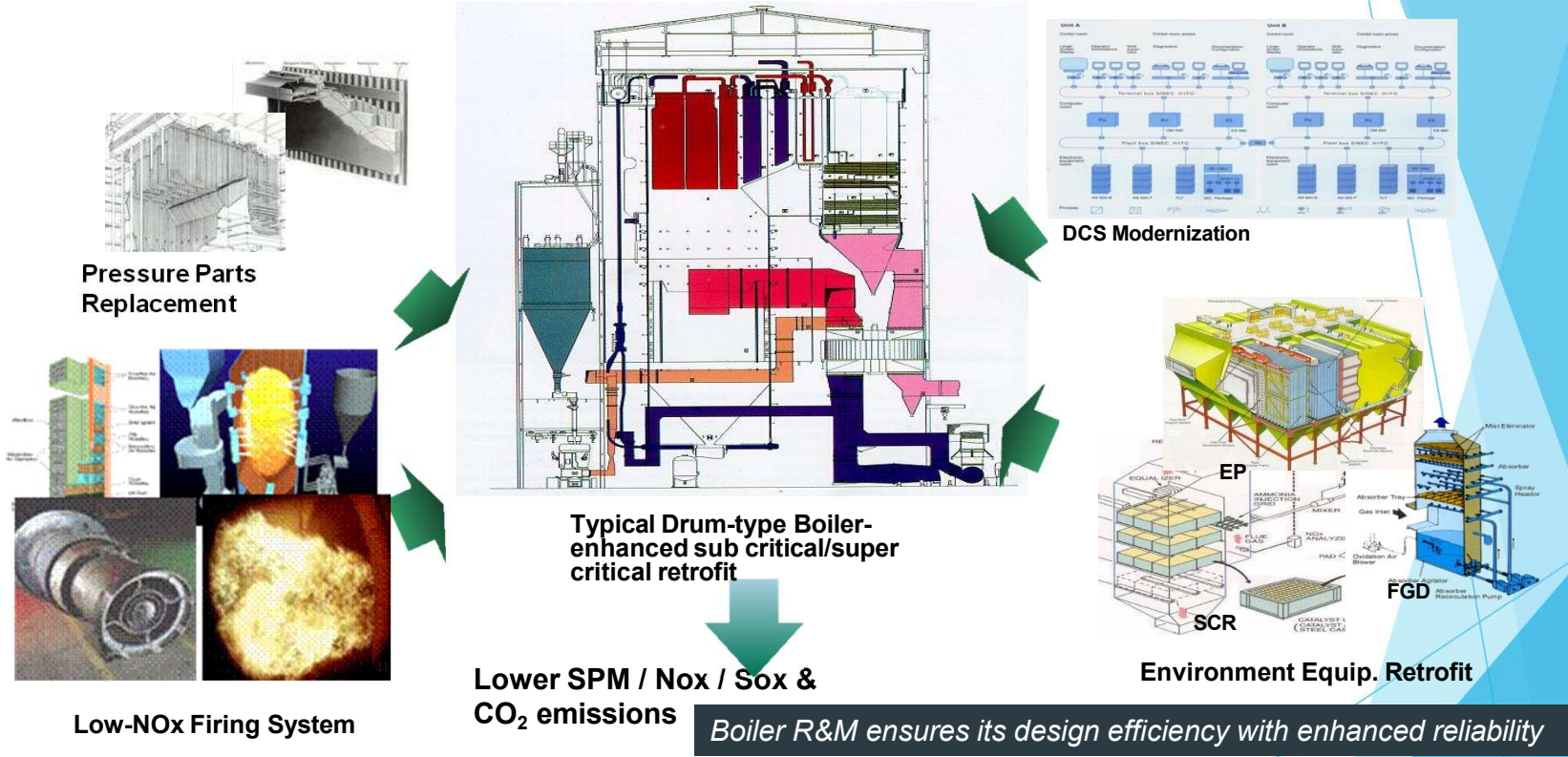
Performance Improvement



Advanced Brazing Materials



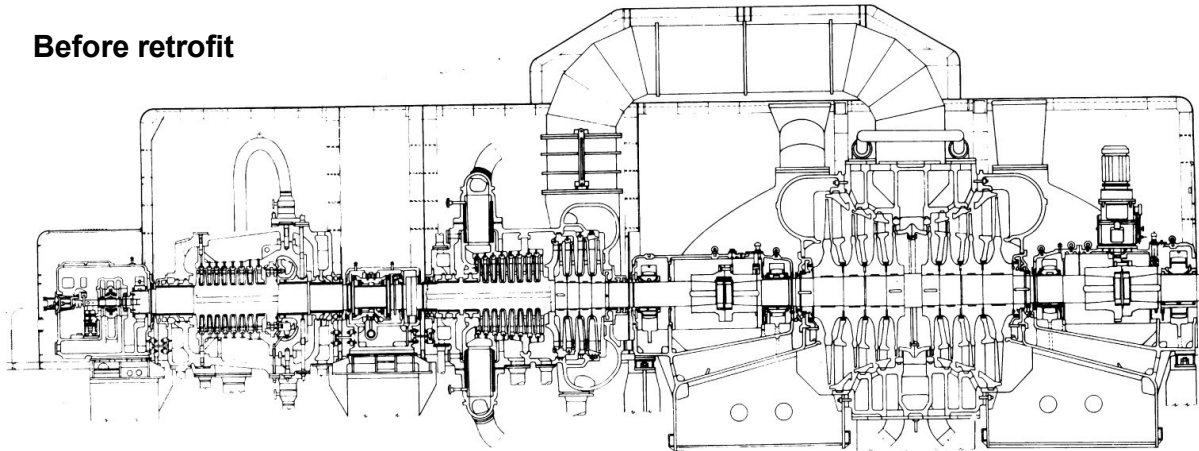
Energy Efficient R&M solution for both Wall-fired & Corner fired boilers



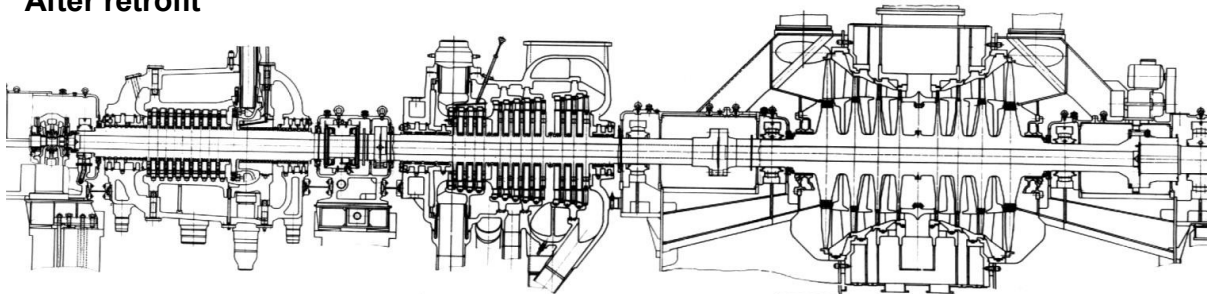
40+ years old plants are still in service in the world meeting present day environmental standards and enduring power trading market forces with retrofits

Energy Efficient R&M with capacity upgrade of 2 x 110 MWe Sub-critical Units

Before retrofit



After retrofit



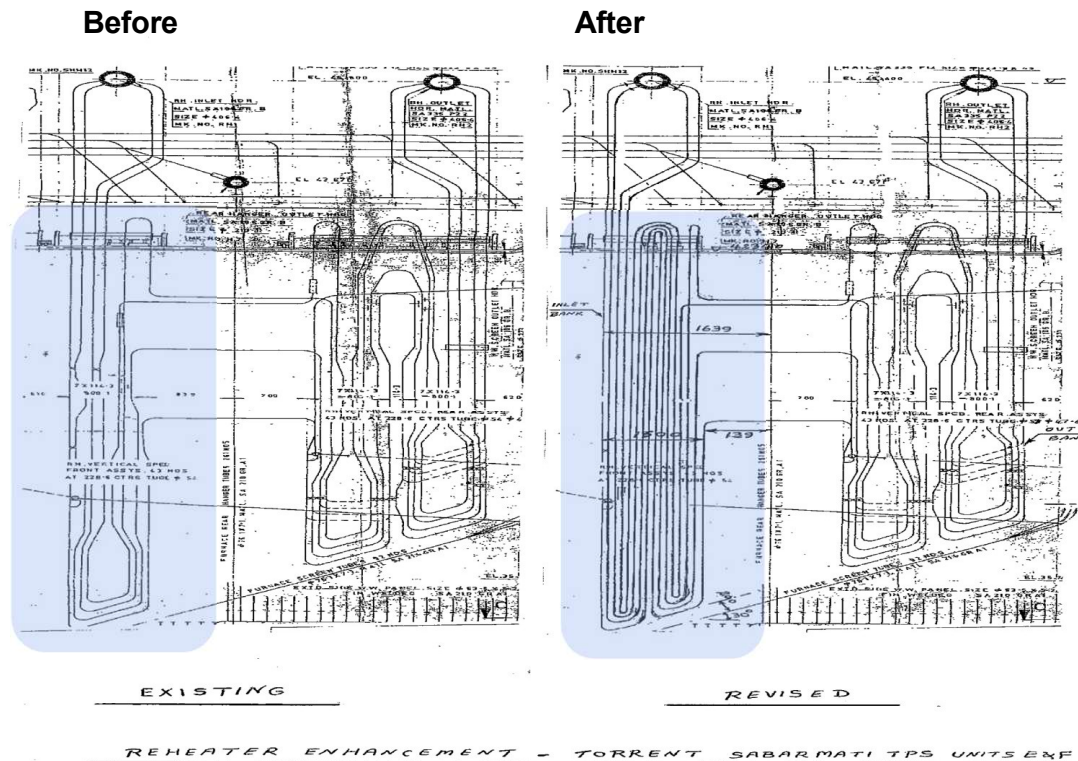
Objective

- TBN Heat rate
 - 8% ↓ (2175 => 1999 Kcal/KWh)
 - 25% ↓ (from Present condition)
- MW output
 - 11MW ↑ (110 => 121 MW)
- Life time extension
 - 120 000 hours

Scope of Works

- HP, IP, LP Steam Path Upgrade/Replace
- Regenerative Equipment Upgrade

Boiler Design upgrade to suit R&M with capacity upgrade of the 110 MWe TG



Objective

- Re-Heater Modification to accommodate up-rated steam condition by retrofitted turbine

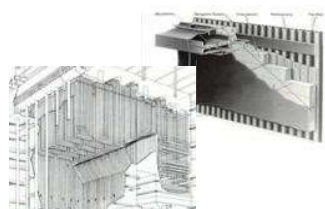
Scope of Works*

- Boiler modelling
- Performance check for new HBD
- New re-heater surface with inlet and outlet headers
- CDS tubing for re-heaters to reduce pressure drop and accommodate extended surface

210 MWe Bandel Energy Efficient R&M Objectives and guarantees

Objectives	Targets	Guarantees achieved
Unit Capacity	Increase from 210 MWe to 215 MWe	215 MWe
PLF	80% from present level of approx. 60% avg.	PLF as per grid requirement
Gross Unit Heat Rate	2456 Kcal/Kwh from present levels of approx. 3000 Kcal/Kwh	2345 Kcal/KWh
Auxiliary Power Consumption	13.5 MW for key auxiliaries	13 MW for key auxiliaries
Fuel diet	Designed for worst coal with Calorific Value of 3300 Kcal/Kg	Designed for worst coal with Calorific Value of 3300 Kcal/Kg
Particulate Emission	90 mg/Nm ³	90 mg/Nm ³
Life Extension	Minimum 15 years	Minimum 15 years

Boiler Island & C&I Scope of work



Major Pressure Parts Replacement for Life extension, reliability and performance improvement

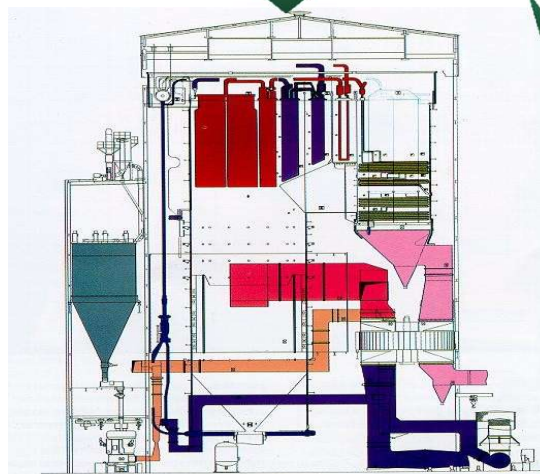


Miller Plant upgrade, New PA Fans, Piping and Gravimetric Feeders



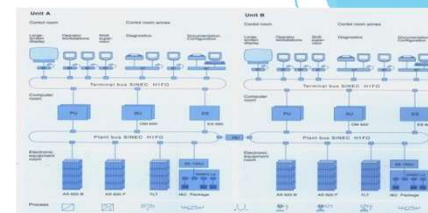
Low-NOx Firing System

New ID, Seal Air and Core Air Fans, refurbishment of FD Fans, Flues and Ducts & Dampers



Typical Drum-type Boiler

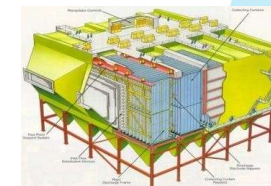
Lower SPM / Nox Emission & Performance Improvement



DCS Modernization Renewal of Field Instruments

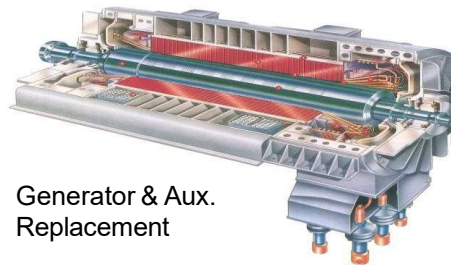
Airheater refurbishment and surface addition for reduced flue gas losses

New sootblowers, replacement/refurbishment of valves and actuators



ESP Environment Equip. Retrofit

Turbine-Generator Island Scope of Work

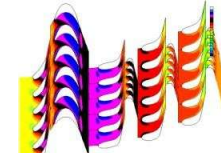
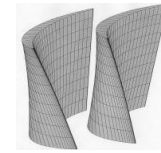


Generator & Aux.
Replacement

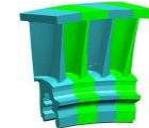
- HP, IP, LP Turbine Replacement
- TG Lub oil system upgrade
- Electro hydraulic governors
- New ESVs, IVs and CVs
- Drains & extraction system refurb.
- Condensor retubing
- New CEPs
- Energy Efficient BFP cartridges
- Drip Pump Refurb.
- HP/LP heater tube nest replacement
- Deaerator tower replacement
- Renew HP/LP Bypass Valves
- Misc. Valves, actuators
- Renewal of Hangers and supports of critical piping + Insulation
- Turbo visory system
- Field Instruments

State-of-art Turbine Technologies

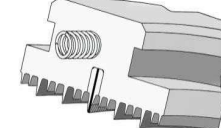
Advanced Blade Technology



Entropy/Velocity
Distribution



Integral Covered
Bucket Design



Advanced Seals

Increased efficiency & capacities allows for quick pay-back of project and reduction in carbon footprint

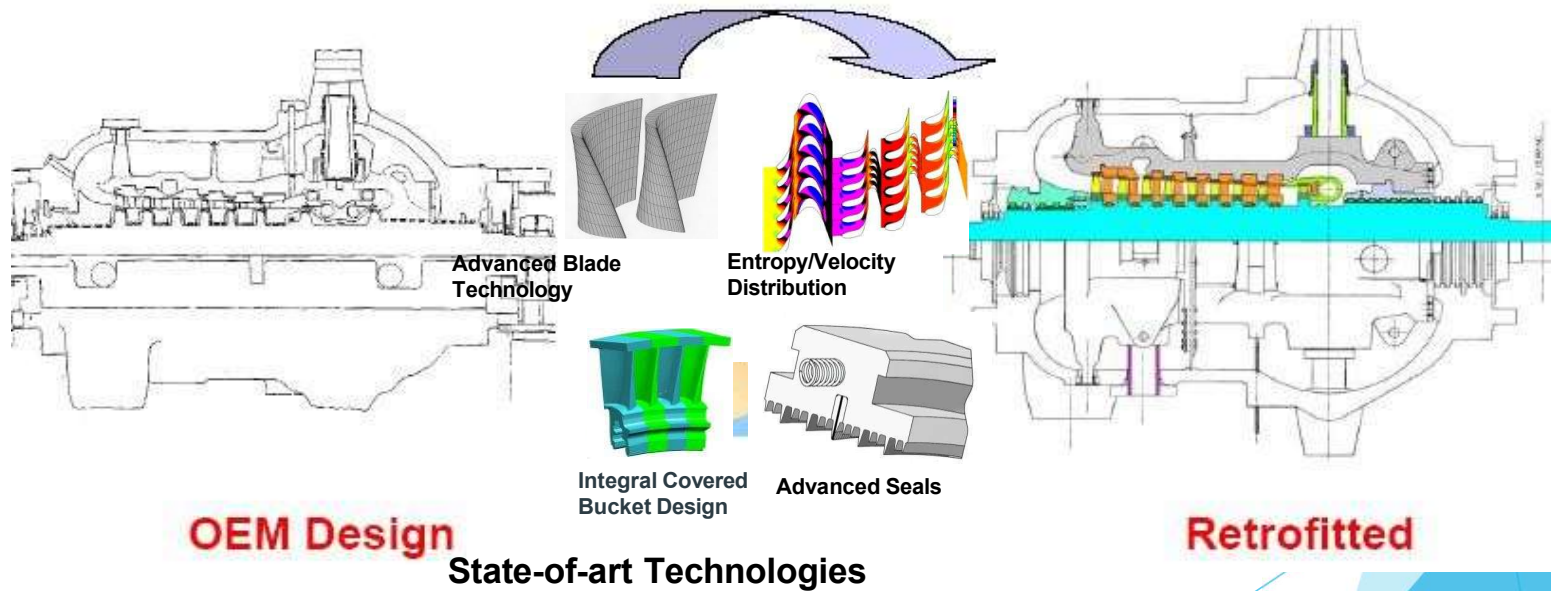
Turbine Retrofit with heat rate improvement

Increased efficiency & hence turbine heat rate improvement is the key to the EER&M:

Approx. 5% improvement over original LMZ turbine design

Approx. 2.5% increase in electrical output

Approx. 2.5% decrease in thermal input



Almost 20% improvement in heat rate from pre retrofit state

BOP Scope to suit plant requirement

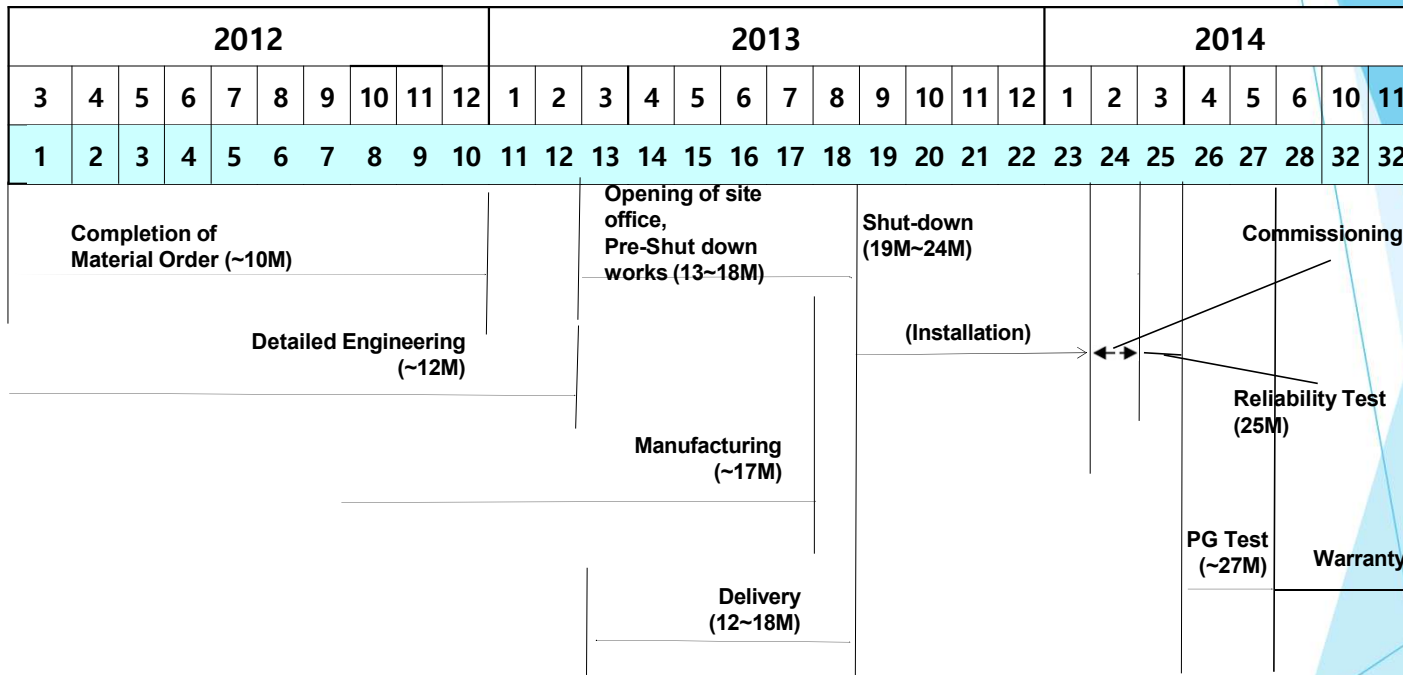
Ash Handling Plant Upgrade

Electrical Systems

Fire system augmentation

Miscellaneous civil foundations as required and control room interiors work

Key Project Milestones of Bandel EER&M

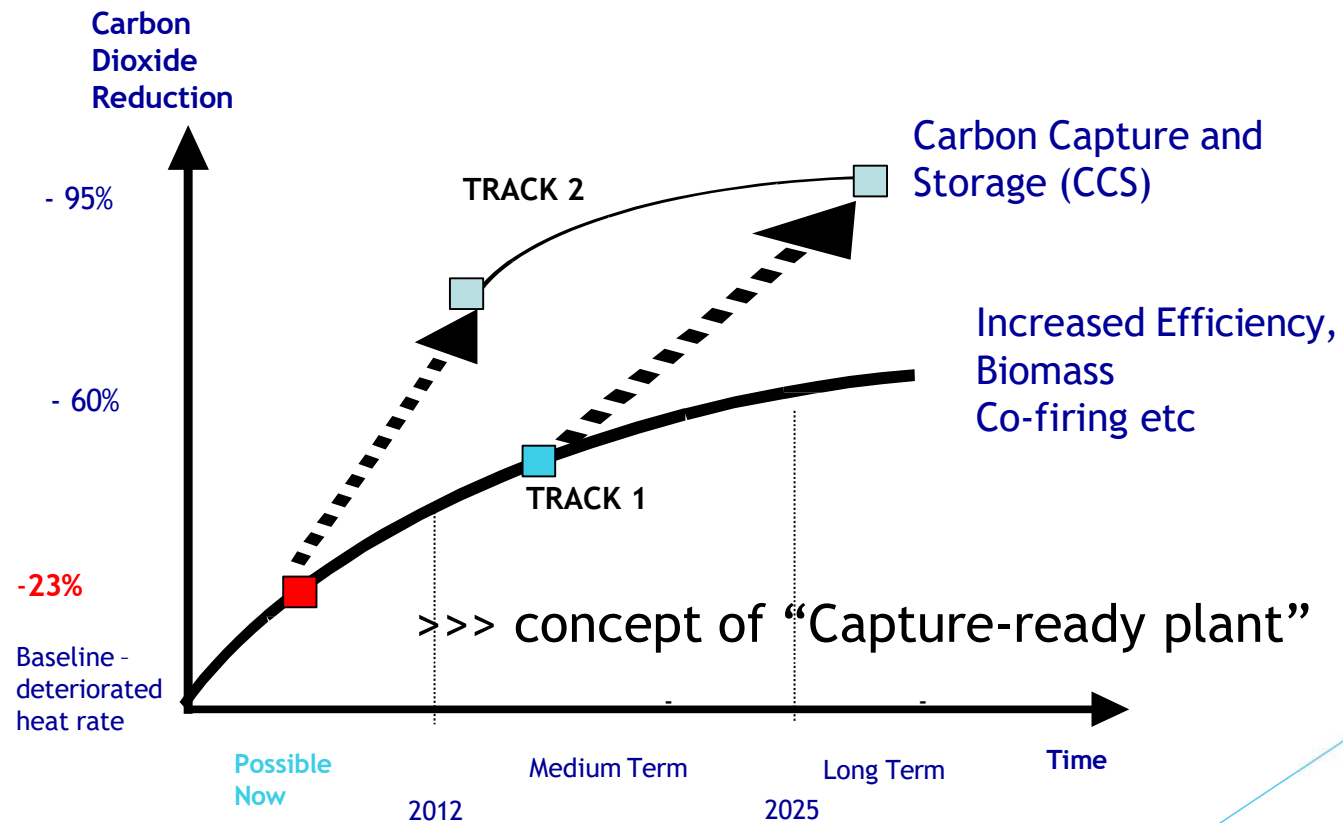


EER&M Project delivered at 50% of new plant cost. Plant continues to operate at full load even after 10~11 years of completion.

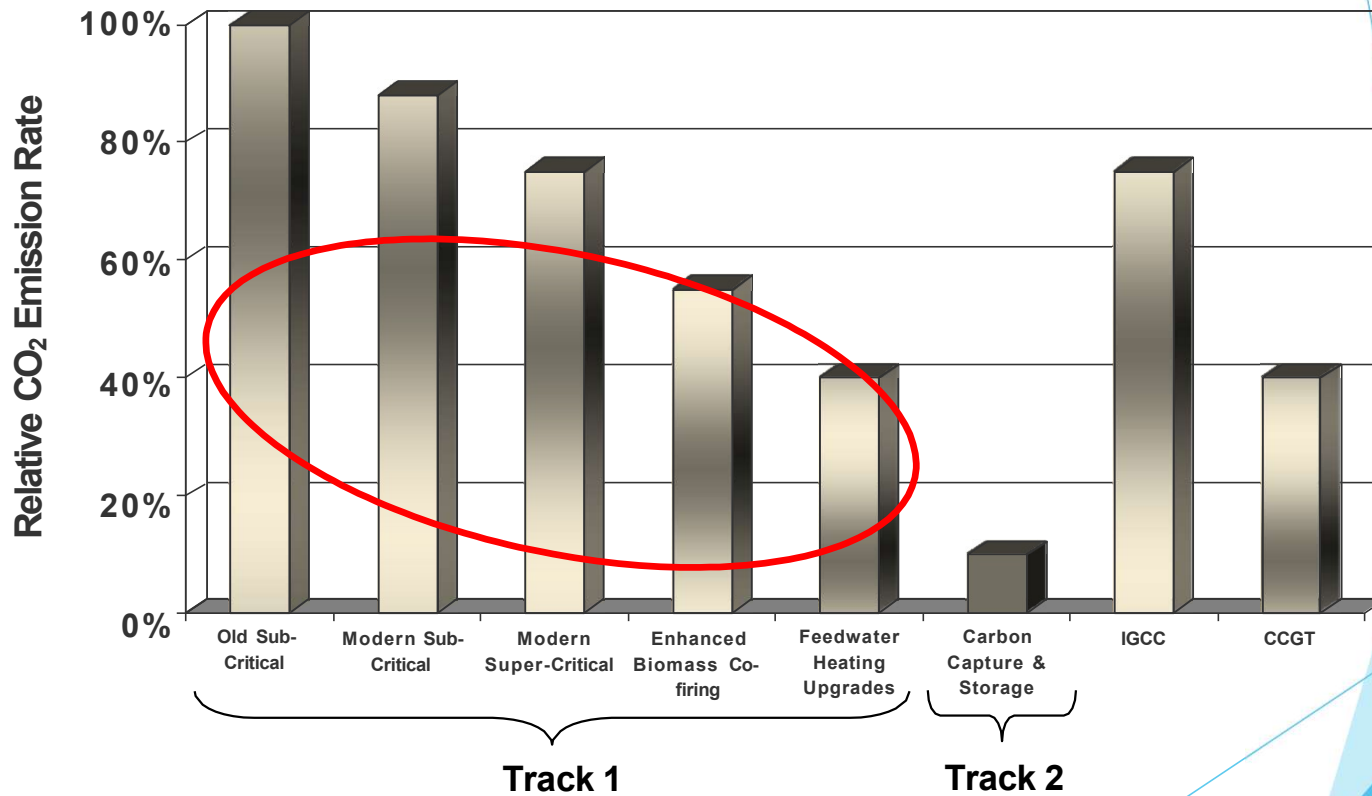


**Advance Supercritical Retrofit of 500 MWe sub-critical units
for plant life extension – concept from feasibility study**

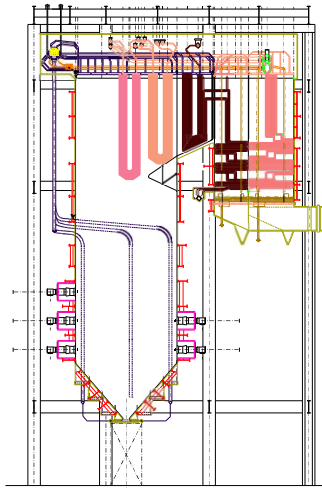
Clean Coal Technologies – Energy Efficiency with CO₂ Abatement from Fossil Fuels – Twin Track Approach



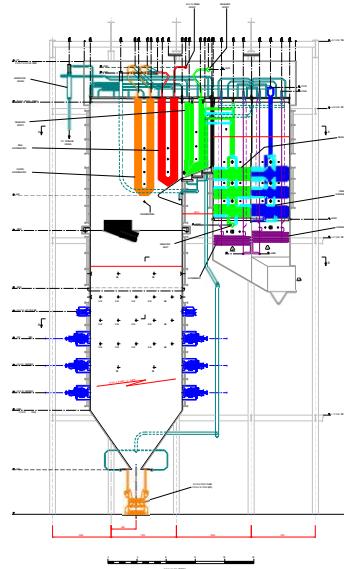
Clean Coal Technology - A Phased Approach towards energy efficiency and CO₂ Reduction



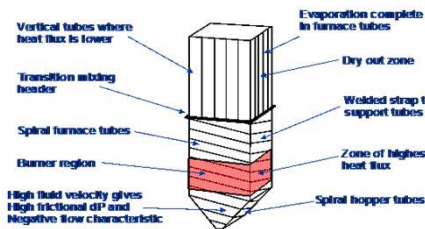
Continuous Technology Innovation – Proven Operation



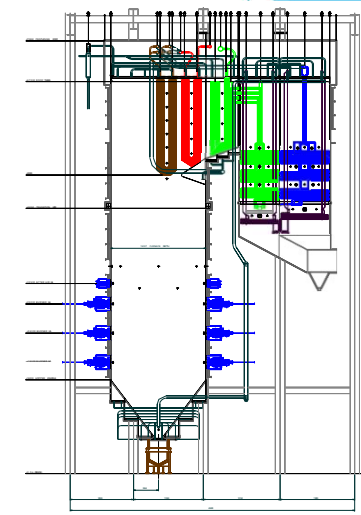
■ Natural Circulation



Once Through



► Supercritical



• Posiflow™

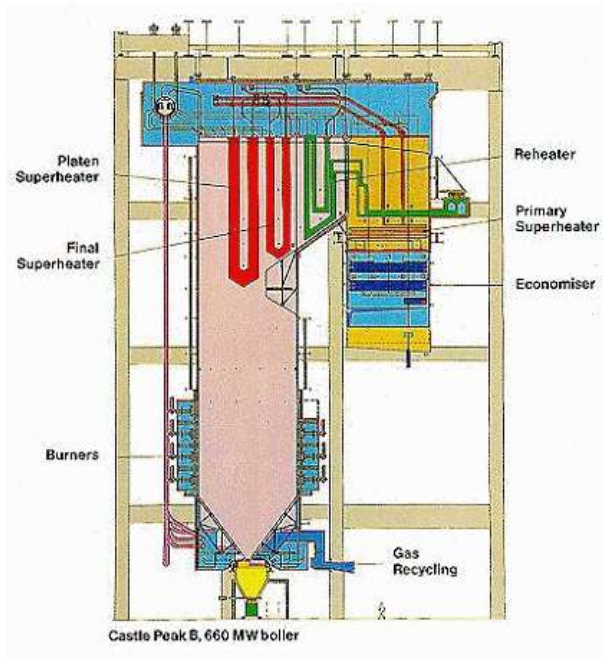
Advanced Supercritical Retrofit Application – a feasibility study

- Unit electrical output maintained
 - 507 MWe Gross / 476 MWe Net (including SCR, FGD)
- Turbine inlet steam conditions
 - 290 bara, 600deg C main steam, 610 deg C reheat steam
- Optimum turbine and thermal cycle retrofit for best techno-economic benefits
- “Posiflow” vertical rifled bore tube low mass flux furnace walls
- Plant to be ‘capture ready’ for future CO₂ capture and sequestration by Oxyfuel combustion process
- 150,000 hour pressure part design life

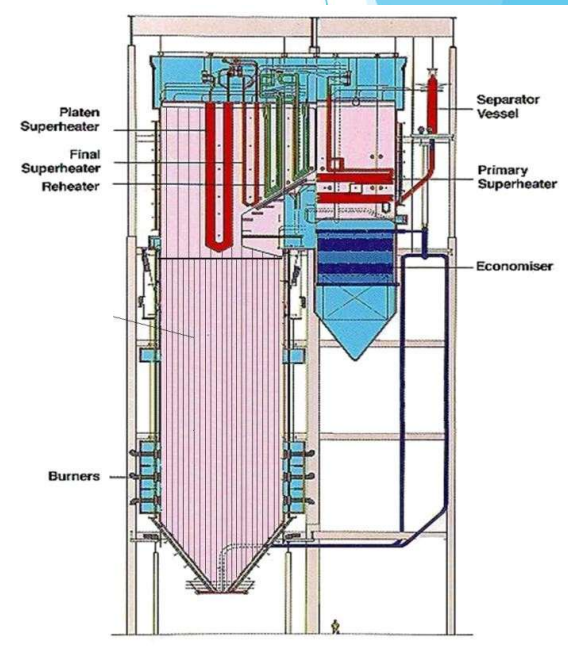
Advanced Supercritical Retrofit Application – a feasibility study

- Current subcritical boiler / turbine unit cycle efficiency 34 ~ 35%
- Anticipated advanced supercritical retrofit cycle efficiency 45% net with AQCS equipment
 - > 25 % increase in overall efficiency
 - A significant improvement in spite of auxiliary power penalty for FGD and SCR

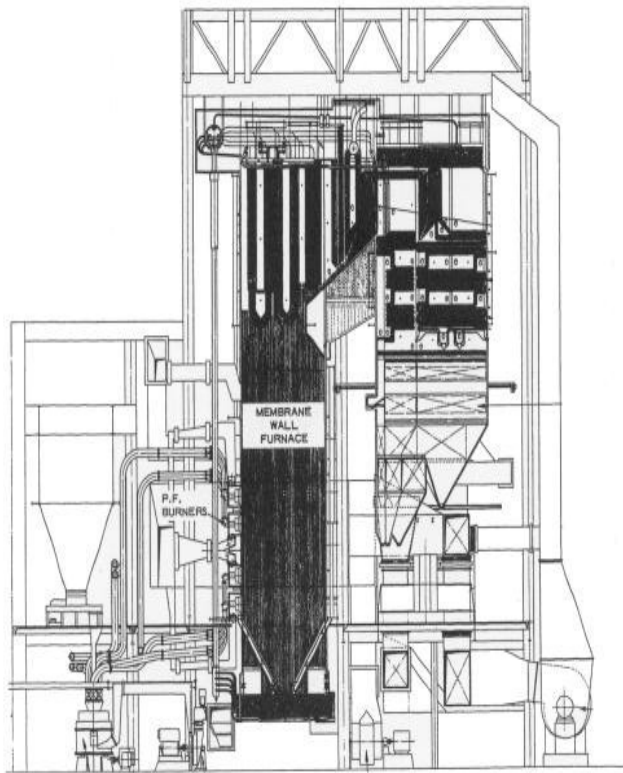
What will a Supercritical Retrofit involve



- Replacement of boiler pressure parts, within boilerhouse envelope
- Lighter boiler weight means re use of existing primary structure
- Replacement of HP and IP turbine, modified LP turbine
- Replacement of all steam and feed water piping
- New feed pumps and feed heating system
- New DCS system (if not already installed)
- Re use of bulk of ancillary equipment
- New SCR plant
- New FGD plant (if not already installed)



Sub-critical / Supercritical Retrofit

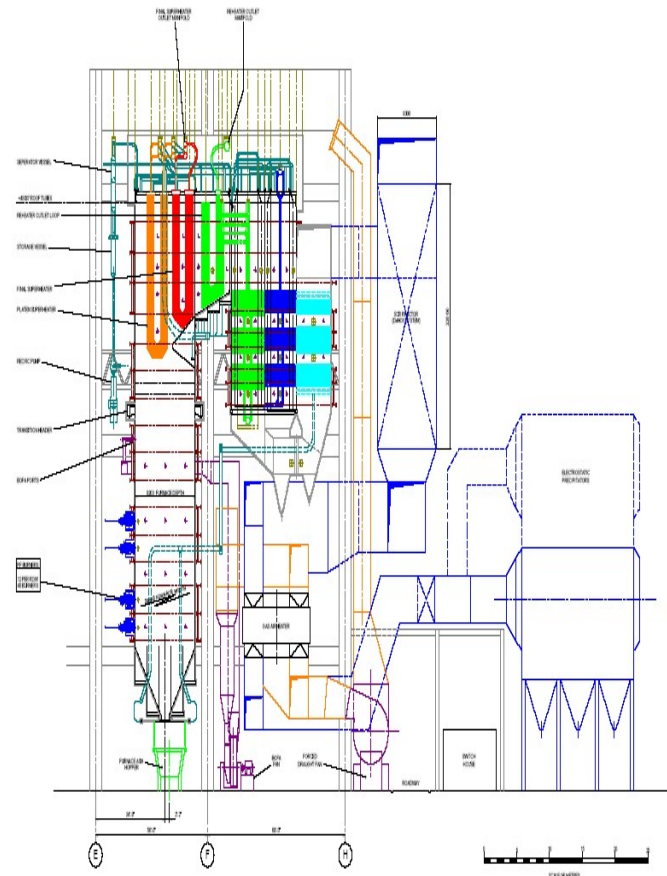


Replacement of boiler pressure parts, within boilerhouse envelope

Lighter boiler weight

Re use of bulk of ancillary equipment

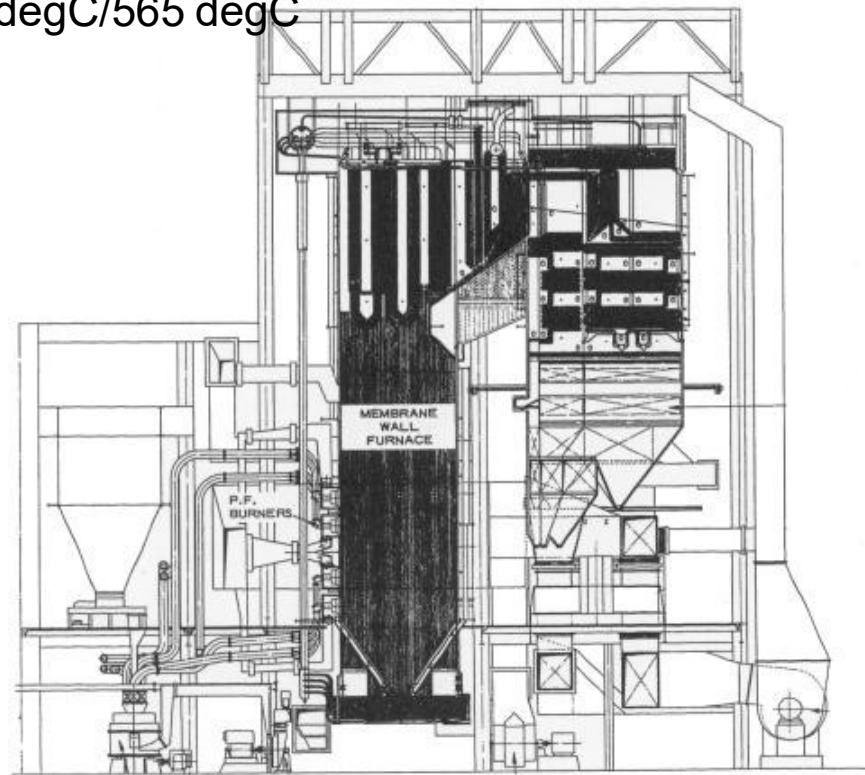
Pipework, turbine & thermal cycle modifications



Assessment of Retrofit Specifics – Present Boiler

Sub critical natural circulation boiler

Steam Conditions: 160 bar/565 degC/565 degC
Feed Water: 240 degC



Boiler Island Component Replacement / Re Use

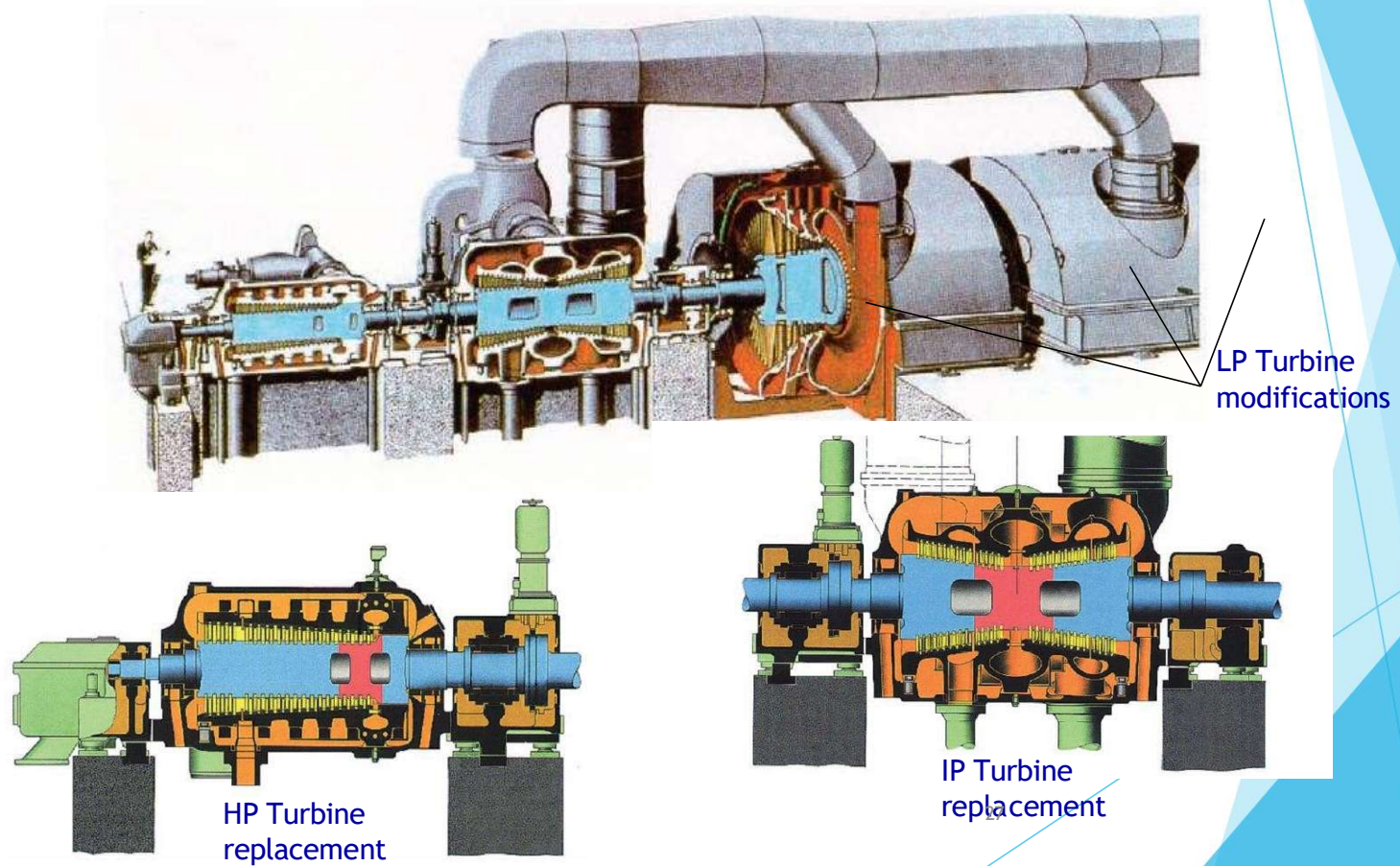
REPLACED / RENEWED COMPONENTS

- Boiler water and steam walls
- Start-up / separator system
- Circulation pump
- Superheaters and reheaters
- Steam Attenuation system including control and isolation valves
- Economiser
- All boiler integral piping
- Flash tank
- Safety valves and silencers
- All boiler valves
- Boiler drains and vents
- Sootblowing steam piping up to PR Station with valves
- Boiler Aux Steam up to PR Station with valves
- Boiler Hot Structure and framing
- Boiler main supporting steelwork modifications
- Ductwork modifications as required
- Insulation, cladding and painting as required
- Field Instrumentation
- Boilerhouse cladding as appropriate

RE USED COMPONENTS

- Boiler supporting steelwork
- Draught Plant
- Airheaters
- PA Fans
- Precipitators
- Milling Plant
- Low NOx Burners
- Two stage combustion system (BOFA)
- Coal feeding system (bunkers, feeders etc)
- PF Piping
- Sootblowers excluding main pressure reducing station and piping
- Boiler Aux Steam System excluding piping from tapping to PR Station
- Flues and ducts / Stack
- Coal and ash handling plant
- Oil handling and pumping system
- Compressed air system – instrument and service air
- Station vacuum plant
- Fire detection and fighting system including hydrants etc
- Boiler auxiliary cooling water system
- All civil foundations
- Boilerhouse structure / building
- Biomass system

Advanced Supercritical Retrofit Specifics: Initial Assessment – turbine retrofit



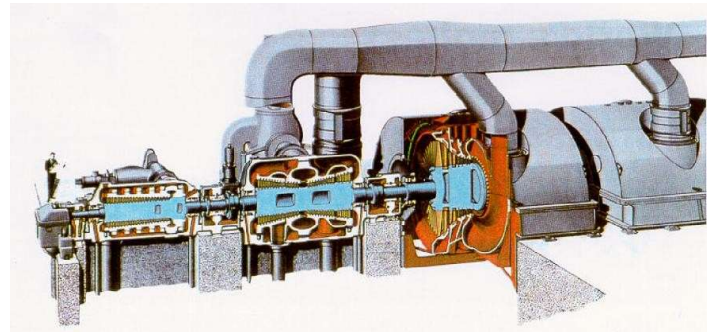
Turbine Island Component Replacement / Re Use

REPLACED / RENEWED COMPONENTS

- HP Turbine Module and Bearing Pedestal
- IP Turbine Module and Bearing Pedestal
- LP Turbine Rotor and Inner Casing
- MS/RH Stop valves, control valves, interceptor valves and steam admission pipes
- Thermal insulation and lagging as required
- Turbine control and protection device, turbo-visor system and ATRS
- Turbine lub oil skid
- Turbine control oil skid
- Turbine local manual test system
- Gland sealing system and cooler refurbishment
- Set of turbine drains
- Condenser Tube bundle replacement
- Starting and main ejector system
- Refurbishment of LP heaters with new tube bundles
- 4 off new HP heaters with mountings
- 3 x 50% Boiler feed pumps, turbine drives, electrics and associated valves
- Turbine steam extraction system
- Generator overhaul
- Excitation system
- Unit Auxiliary Transformer
- Set of field instrumentation for condensate, feed & thermal cycle
- Condensate polishing plant

RE USED COMPONENTS

- All civil foundations
- Generator and auxiliaries and hydrogen cooling system
- stator cooling water pumps
- Generator Transformer
- Generator bus duct, bus bars, protections
- Turbine auxiliaries other than components being replaced
- Condenser except for tube bundles,
- Condensate extraction system
- LP feed heating system except for tube bundles
- Deaerator
- Feed pump suction piping
- Auxiliary cooling water system
- CW Pumps and CW system
- Raw water and DM water system
- Buildings



Piping Component Replacement / Re Use

REPLACED / RENEWED COMPONENTS

- MS Piping with drains and valves
- CR Piping with drains, vents and valves
- HR Piping with drains, vents and valves
- Feed Water piping with drains, vents, valves and sup ports as necessary
- Flash tank
- Turbine Aux Steam piping up to PRDS and PRDS
- Spray Water piping to turbine PRDS with valves
- Spray Water piping to boiler attemperation system
- Field instrumentation



RE USED COMPONENTS

- Piping supports and structures
- Turbine auxiliary steam system beyond PRDS
- Boiler Auxiliary steam system beyond PR station
- All LP Piping



EC&I Component Replacement / Re Use

REPLACED / RENEWED COMPONENTS

- DCS
- BMS integrated into DCS
- Control and signal cables as required for new DCS
- Switchgears for FW Booster pump motors
- Power cables for FW pump, Turbine oil pumps, control oil pumps

RE USED COMPONENTS

- Precipitators controls and electricals
- Coal and ash handling plant controls and electricals
- HT & LT switchgears
- Station and Aux. Boards
- LV and HV cabling excluding FW booster pumps, turbine oil pumps and control oil pumps
- UPS
- All HT & LT transformers excluding Unit Aux transformer
- Emergency power system – DG Sets
- DC power system
- Switchyard
- Buildings (equipment and control room)
- Lighting
- Paging and telephone system



Advanced Supercritical Retrofit Application – a feasibility study

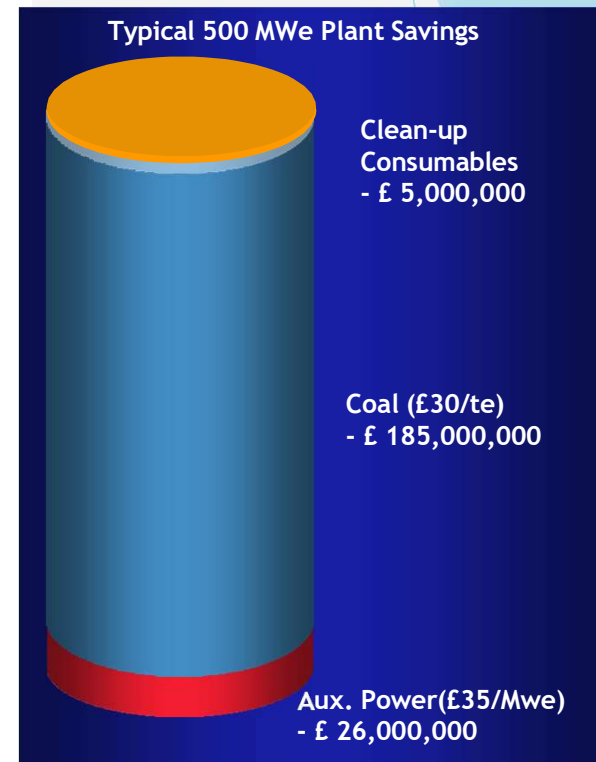
- Emission reductions, at a load factor of 70%, are
 - CO₂ emissions 483,500 te/yr (18%)
 - NO_x emissions 5,100 te/yr (75%) with SCR
 - SO₂ emissions 44,600 te/yr (96%) with FGD
 - Dust emissions 270 te/yr (50%)

Advanced Supercritical Retrofit Application Conclusions

- ▶ No technical show stoppers
- ▶ Unit electrical output maintained
 - ▶ 520 MWe Gross / 480 MWe Net (including SCR, FGD)
- ▶ Turbine inlet steam conditions
 - ▶ 280 bara, 600deg C main steam, 610 deg C reheat steam
- ▶ Optimum turbine and thermal cycle retrofit for best techno-economic benefits
- ▶ “Posiflow” vertical rifled bore tube low mass flux furnace walls
- ▶ Plant to be ‘capture ready’ for future CO₂ capture and sequestration by Oxyfuel combustion process
- ▶ 150,000 hour pressure part design life

Advanced Supercritical Retrofit Application – Estimated Savings due to Energy Efficiency compared to equivalent sub critical unit

- **Capital Costs are comparable for same MWe**
 - Materials are higher grade
 - Flues & ducts and Auxiliary equipment smaller
 - Installed boiler weight similar to sub-critical
- **Through life costs significantly reduced**
 - Coal Consumption
 - Clean-up Consumables
 - Limestone for FGD
 - Ammonia for SCR
 - Auxiliary power
 - Feed Pump (addition)
 - Cooling Water
 - Ash Removal
 - Mills and Fans
- **Lower emissions/MWe**
 - CO₂, NO_x, SO_x, Mercury



UK Plant Reference

Net saving over 25 years £ 216,000,000

Thank You

Sarajit Sen –

Managing Director SMARTLùth Solution and Service Pvt. Ltd.,

Former Managing Director DOOSAN Babcock India (Power Service Group).

Former Head of Business Development Babcock UK (boiler and environmental retrofit business for the European Market).

Former Principal Engineer Babcock UK (Field Engineering and commissioning.)