An Update on Performance Optimization and Efficiency Improvement Programs Completed at State Electricity Board Operated Coal Fired Power Plants in India

Through the Asia Pacific Partnership on Clean Development and Climate (APP)

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Track 4: Operating & Servicing Plants
Session: Performance Management & Optimization
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SERVICE QUALITY RESULTS
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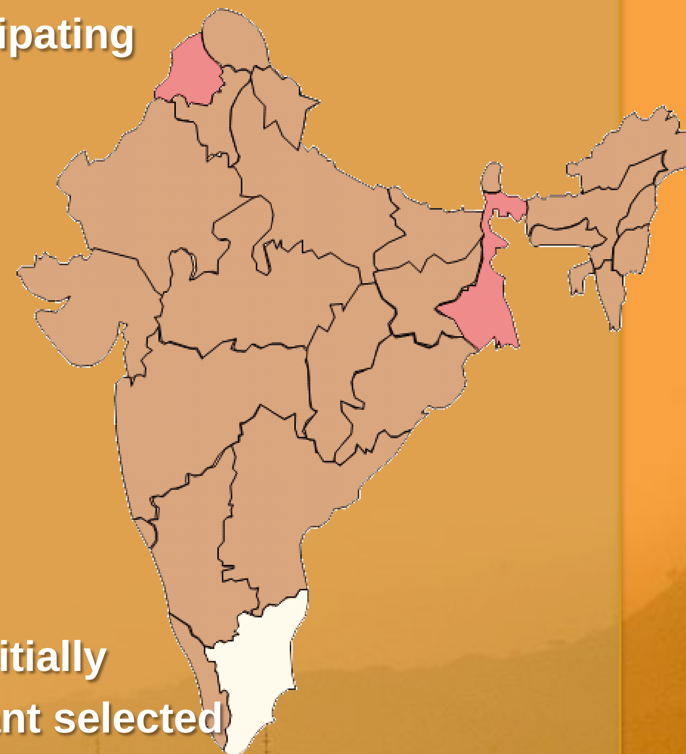
Objectives

- A three-phase combustion optimization and efficiency improvement training program started in 2008 and continues throughout 2009
  - Phase I - Classroom training in India for participating utilities engineers
  - Phase II - Training and demonstration of best practices and testing techniques for participating utilities engineers in U.S. power plants
  - Phase III - Demonstration of testing & evaluation of efficiency at the selected power Plants



- Plant Selection (2008 - 2009)
  - Two (2) state utilities selected to participate initially
  - One (1) 210-MW unit from each state utility plant selected
  - Work with the third utility is in progress in Southern India

Program Development – Phase I

(14 Areas of Evaluation)

1) Fuel Line Clean Airflow Testing
   a) Balance and distribution evaluation
   b) Minimum airflow set-point evaluations
2) Primary Airflow Measurements and Calibration Tests
   a) Evaluation of the transport airflow to the mills, air/fuel ratios and the heat balance for each milling system.
3) Dirty Airflow and Isokinetic Coal Sampling via the STORM Method
   a) Fuel line distribution, balance and air-fuel ratios
   b) Representative coal fineness for each fuel pipe
4) Secondary Airflow Measurements and Calibration Tests
   a) Evaluation of total combustion airflow to the unit
5) Furnace Exit HVT Traverses
   a) Determination of actual flue gas oxygen, temperature, and carbon monoxide profiles
   b) Comparison of actual furnace exit gas temperature vs. temperature gun
6) Air In-Leakage Survey (4 Major Regions)
   a) Furnace exit
   b) Economizer outlet
      i. Comparison of actual boiler oxygen vs. control indicated
   c) Air heater outlet
   d) ID fan discharge

Test Program Protocol Cont'd

7) Flue Gas Flow Measurement

8) Boiler Efficiency & Heat Rate Evaluation

9) Fly Ash Particle Size and Bottom Ash LOI Analyses

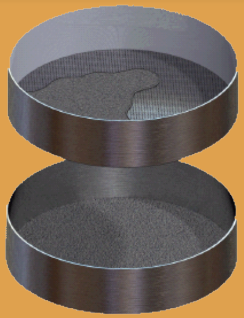
10) Tuning and Optimization

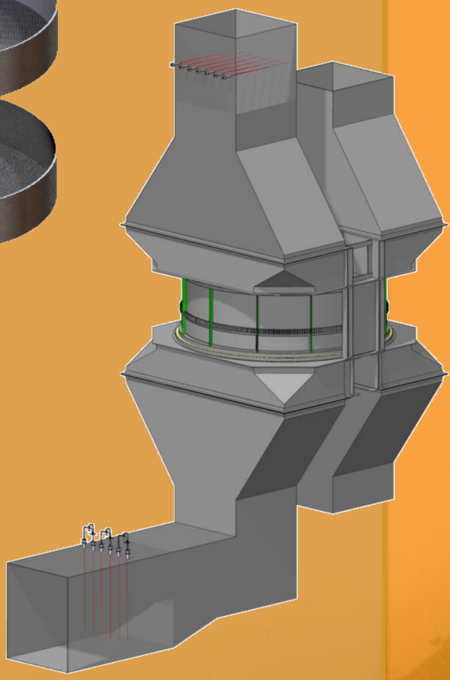
11) Fly-Ash and Bottom-Ash LOI Results

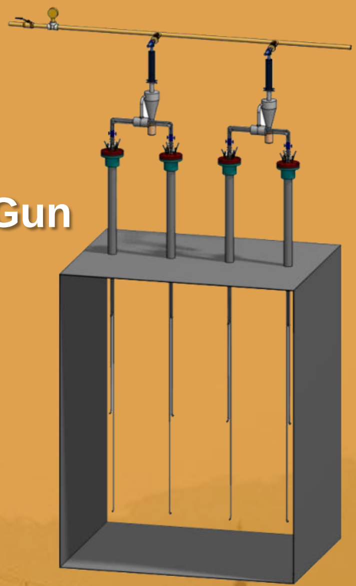
12) Radiant Losses/Survey with Temperature Gun

13) Control Indications Evaluation

14) Analytical Evaluation



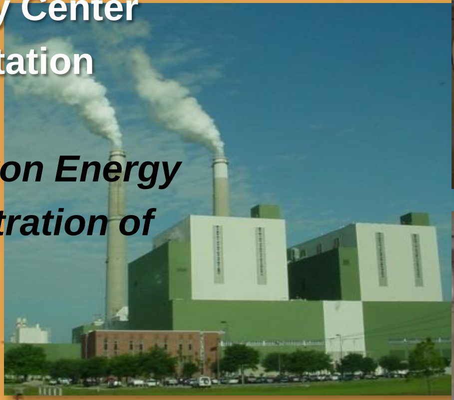




Phase II - U.S. Training

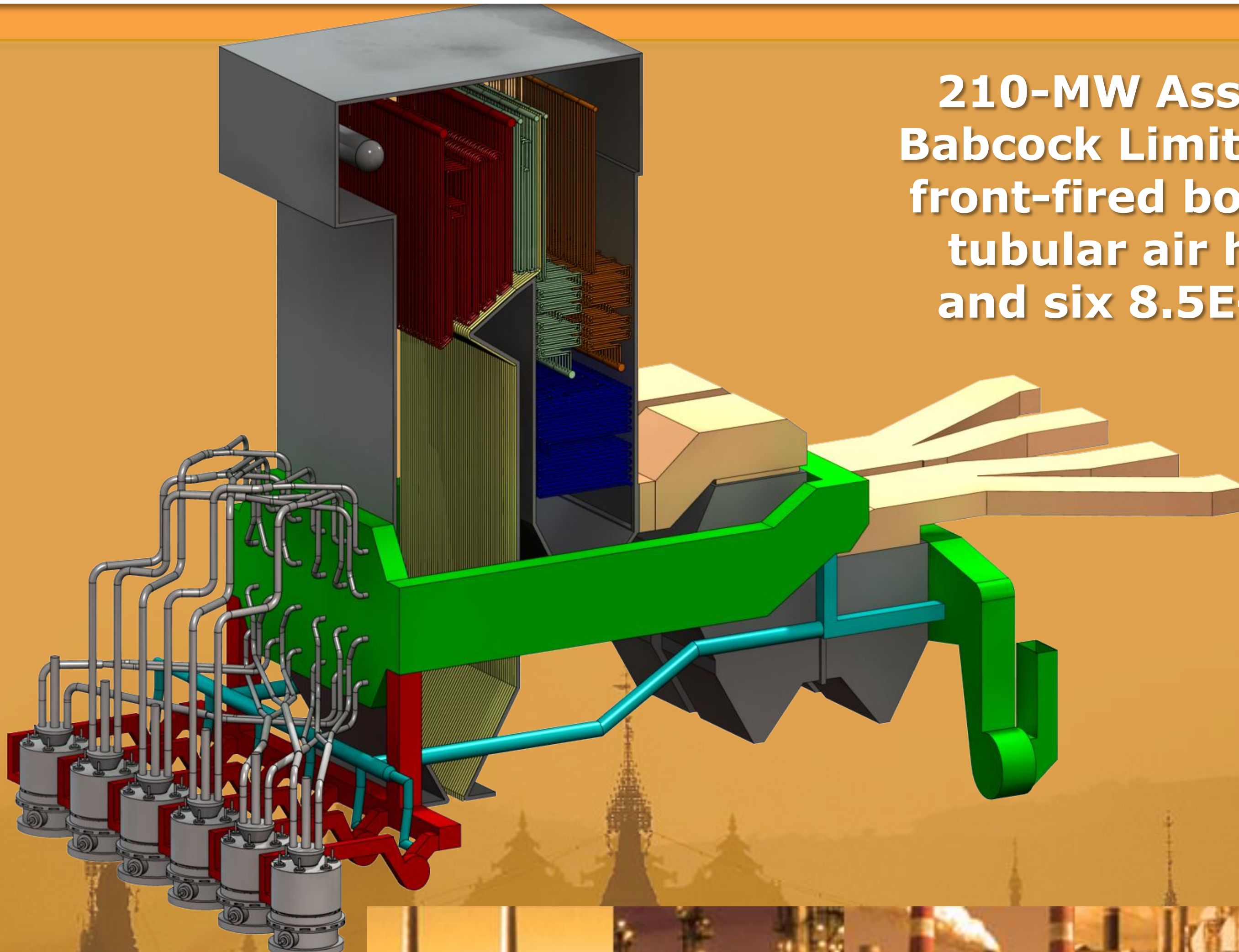
- **Representatives from the state utilities plants visited the United States power plants to learn through demonstration of combustion optimization testing techniques and observe first-hand best practices**
- **Training sites include:**
  - **Reid Gardner Power Station (Nevada)**
  - **Orlando Utilities, Stanton Energy Center**
  - **E.ON – U.S.'s Trimble County Station**

- ***Orlando Utilities Commission's Stanton Energy Center was the site used for demonstration of performance testing techniques***



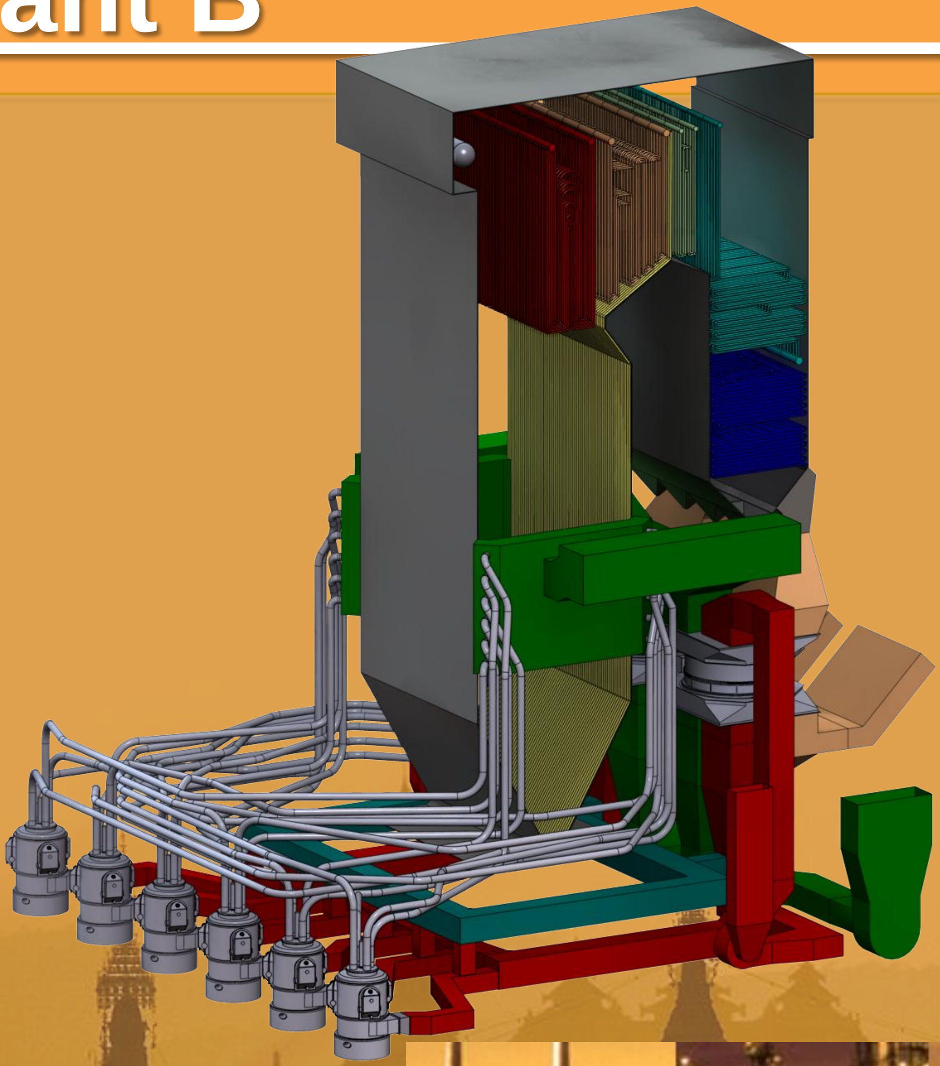



Plant A Phase III



210-MW Associated Babcock Limited (ABL) front-fired boiler with tubular air heaters and six 8.5E-9 mills

Plant B Phase III

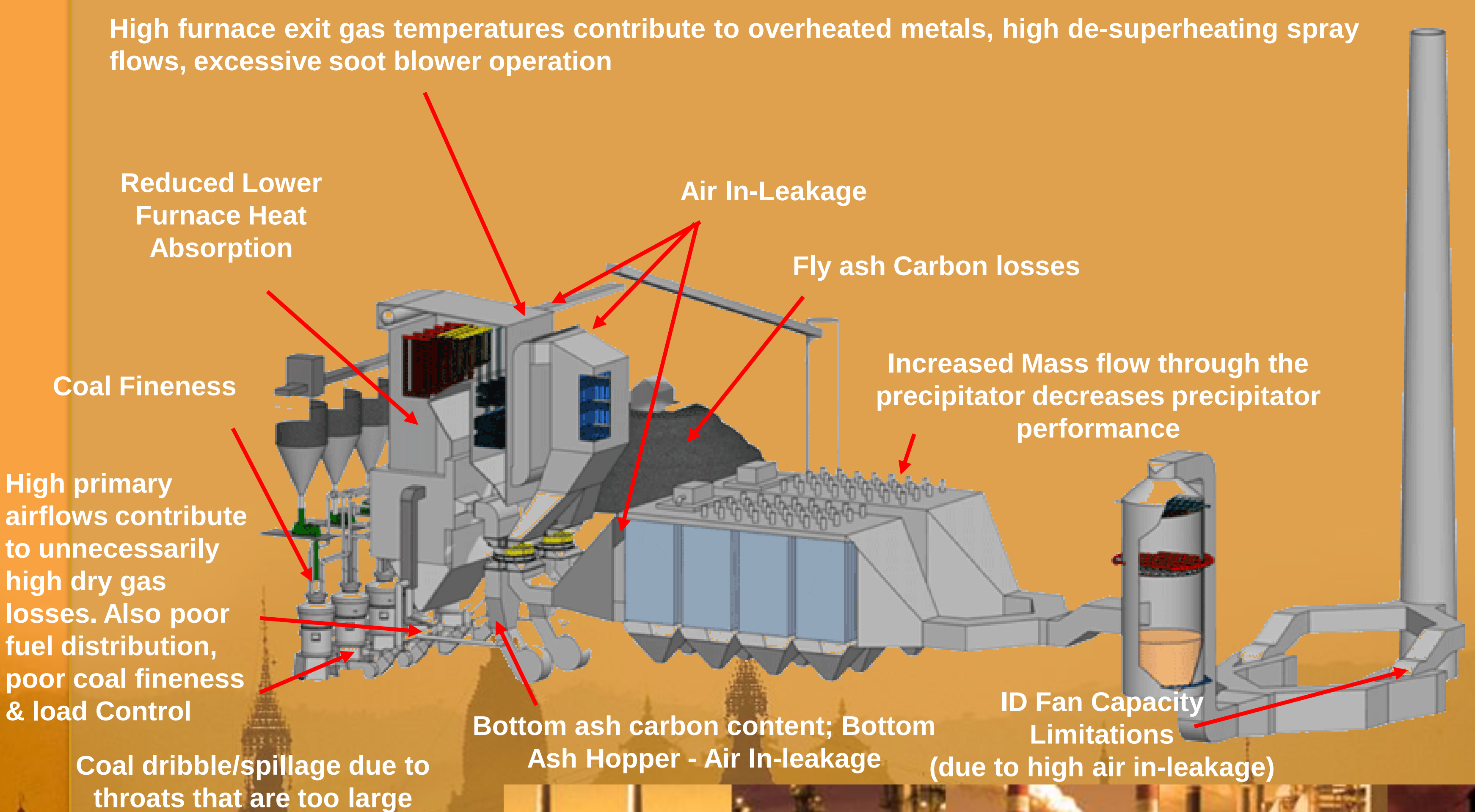


Tangentially-fired boiler Supplied by Bharat Heavy Electricals Limited (BHEL), with regenerative air heaters and XRP mills

Challenges Identified

- **Efficiency & Fuel Conservation**
  - Heat Rate & GTCHR (Steam Cycle) Challenges
    - System efficiency related issues are impacting coal consumption, efficiency & CO_2 production
- **Reduced Generation**
- **Coal Supply**
  - Supply Shortage
  - Variations in Fuel Quality (2,500kcal – 4,000kcal/kg)
    - increased levels of CO_2 emissions attributable to coal blending & deviations from design specification. Despite stable carbon content, fuel consumption is nearly twice the design values
    - unnecessary supplemental fuel consumption impacting heat rate

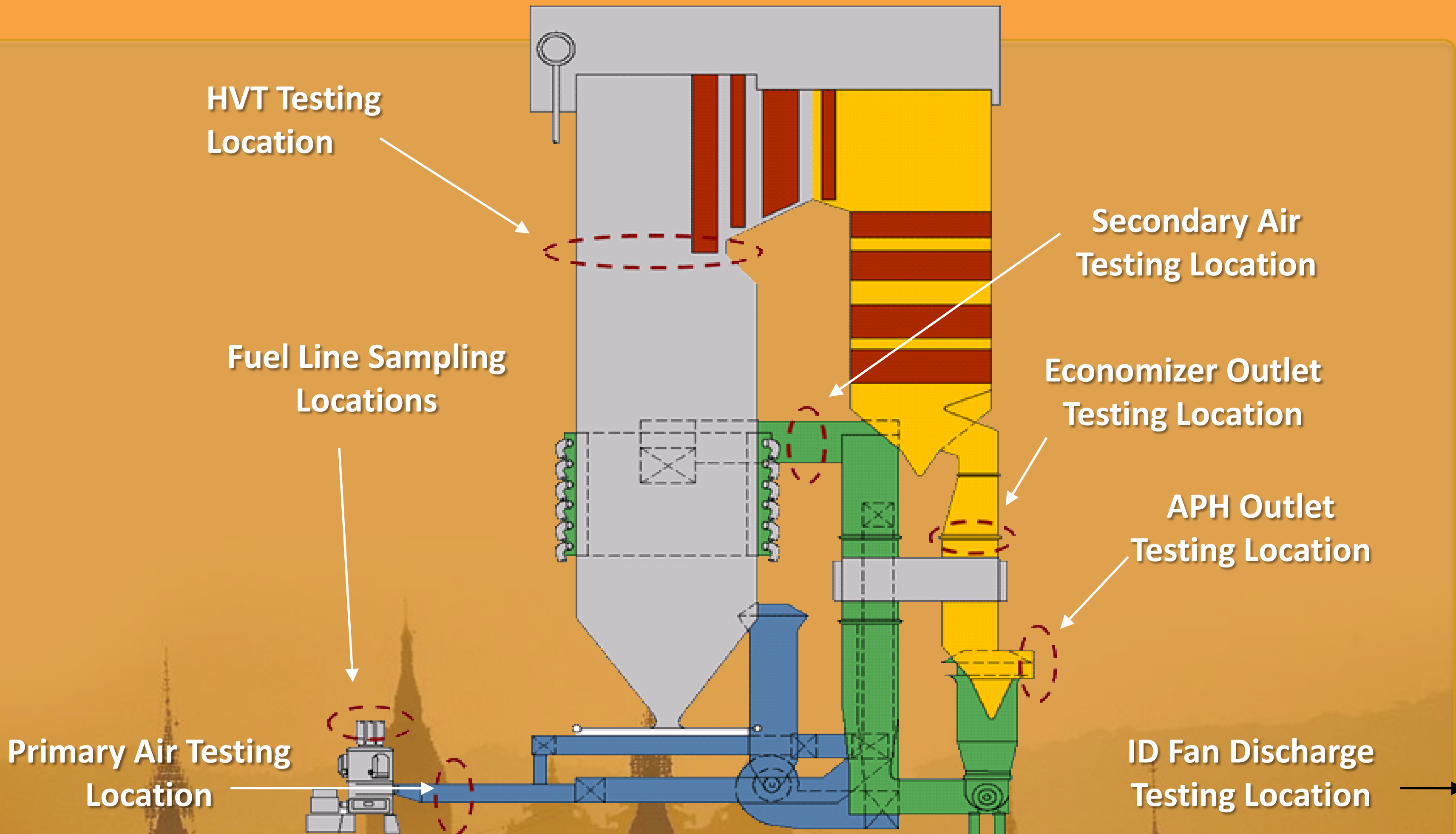
Typical Thermal Plant Performance Opportunities



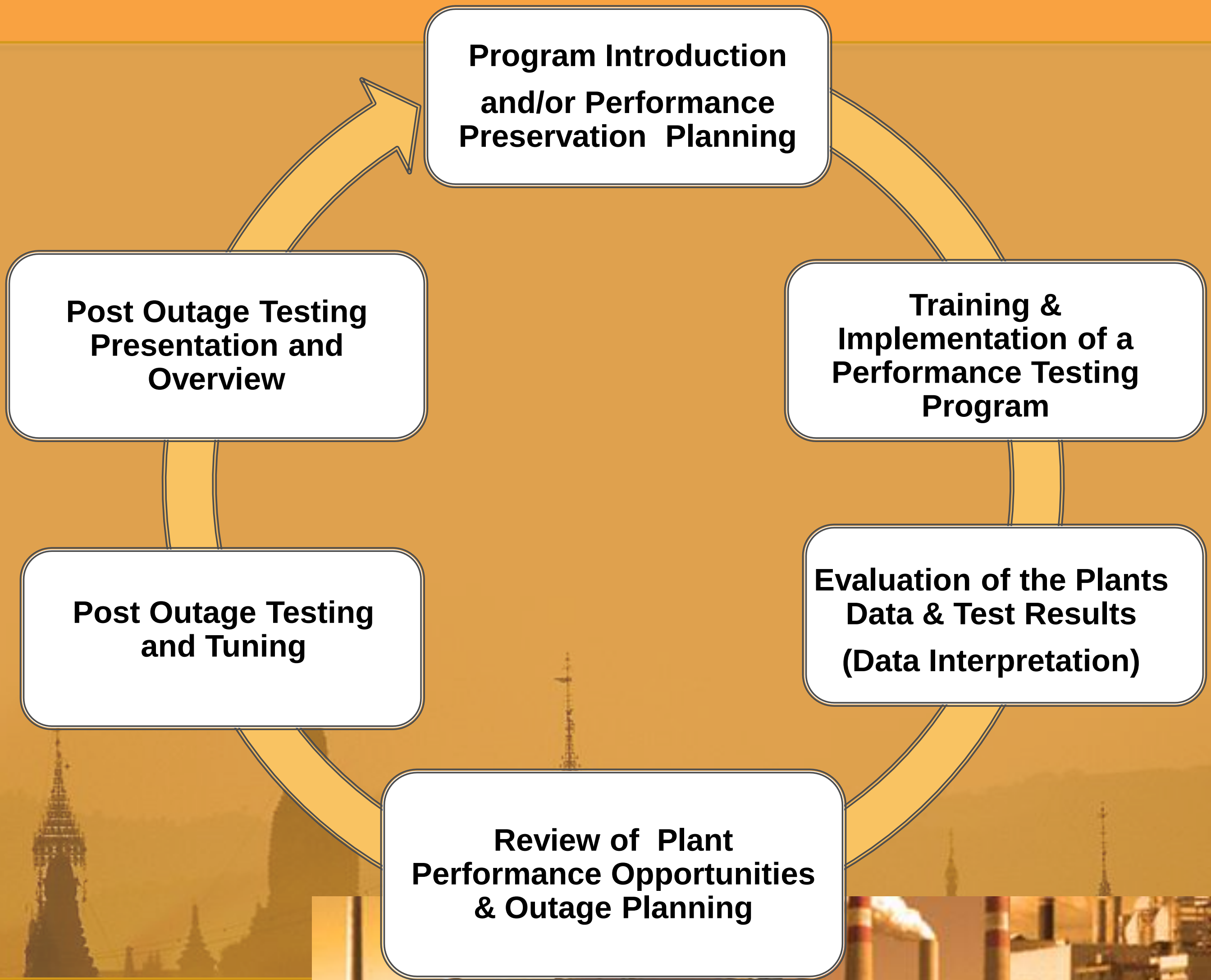
Evaluations Performed

- Gross Turbine Cycle Heat Rate (GTCHR)
- Fuel Line Performance Measurements
- Mill Inlet Primary Airflow Calibrations
- Total Secondary Airflow Measurement & Calibration
- Furnace Exit Gas Temperature & Flue Gas Constituents
- Economizer Outlet Flue Gas Measurements
- Fly ash & Bottom Ash ~ UBC Measurements
- ID Fan Discharge / Stack Inlet Flue Gas Measurements
- "Stealth Loss" Evaluation

Performance Testing & Input Optimization

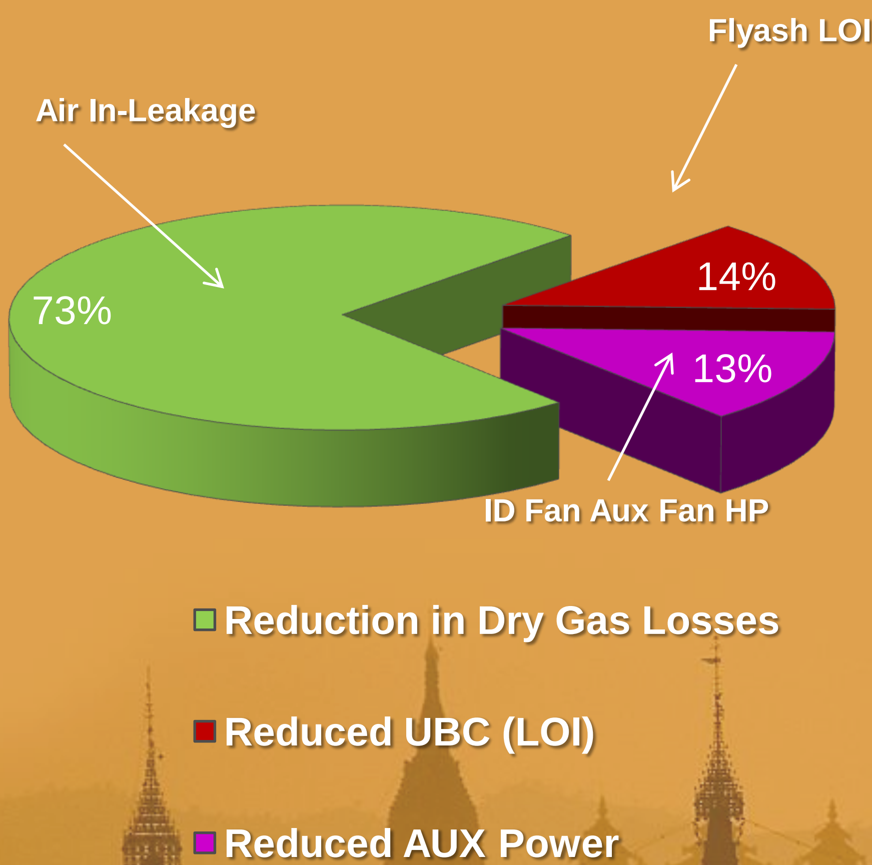


Six Basic Steps of the APPLES* Program



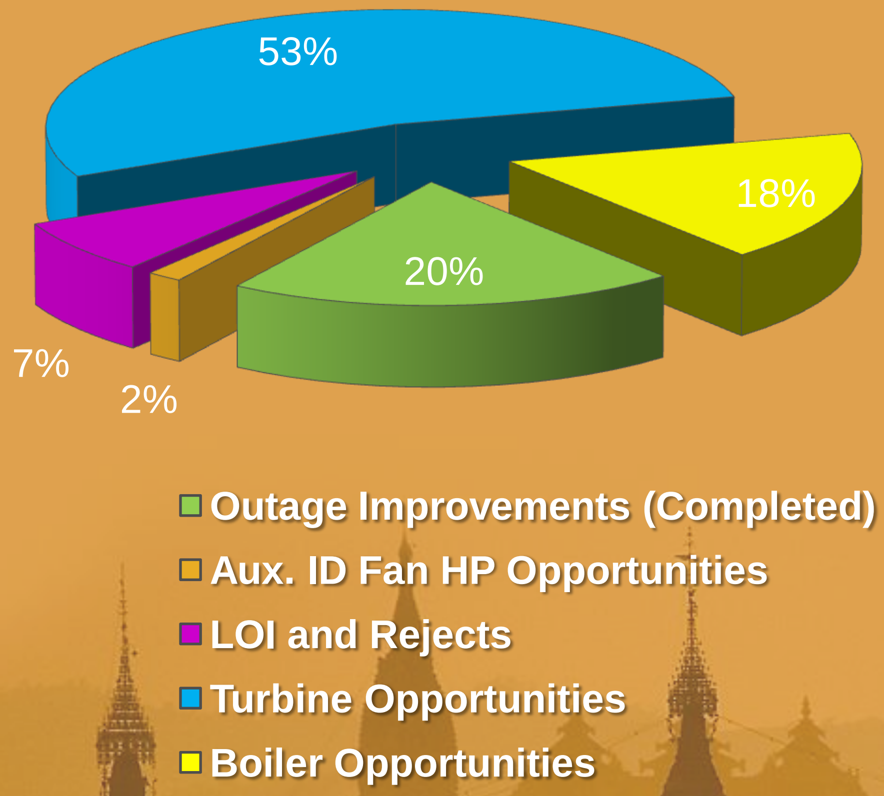
** Annual Plant Performance Evaluation Services*

Pre-Testing Documented Improvements



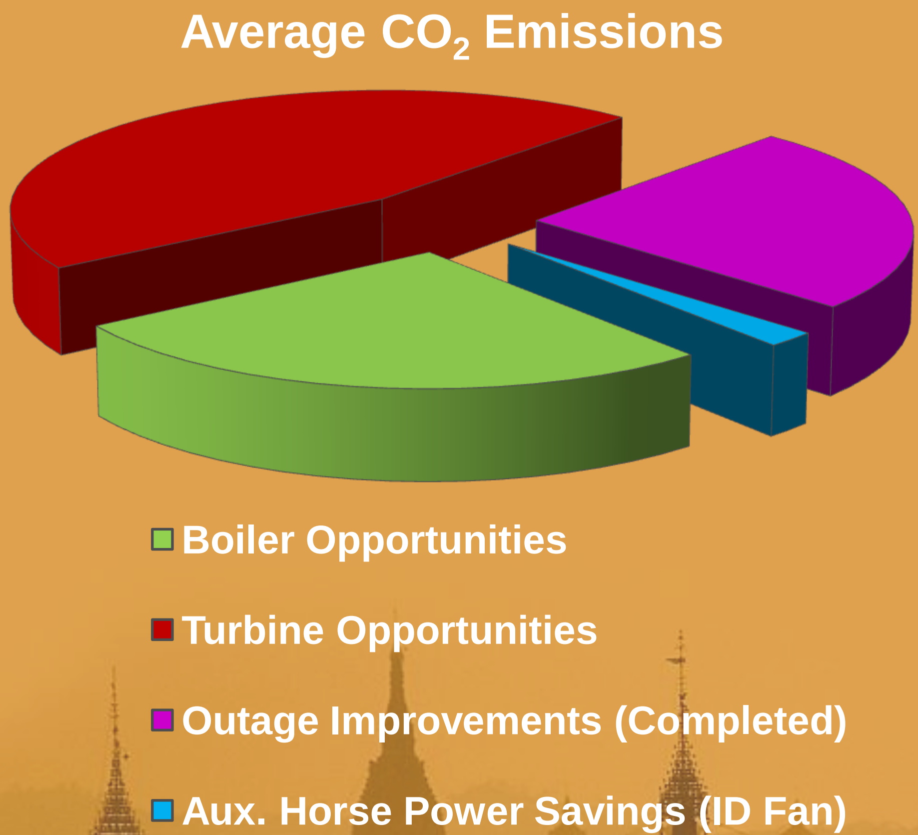
- Recommendations implemented during the outages resulted in heat rate improvement of 75kcal/kWh(293btu/kWh) on the average

Impact of Controllable Losses on Plant Efficiency



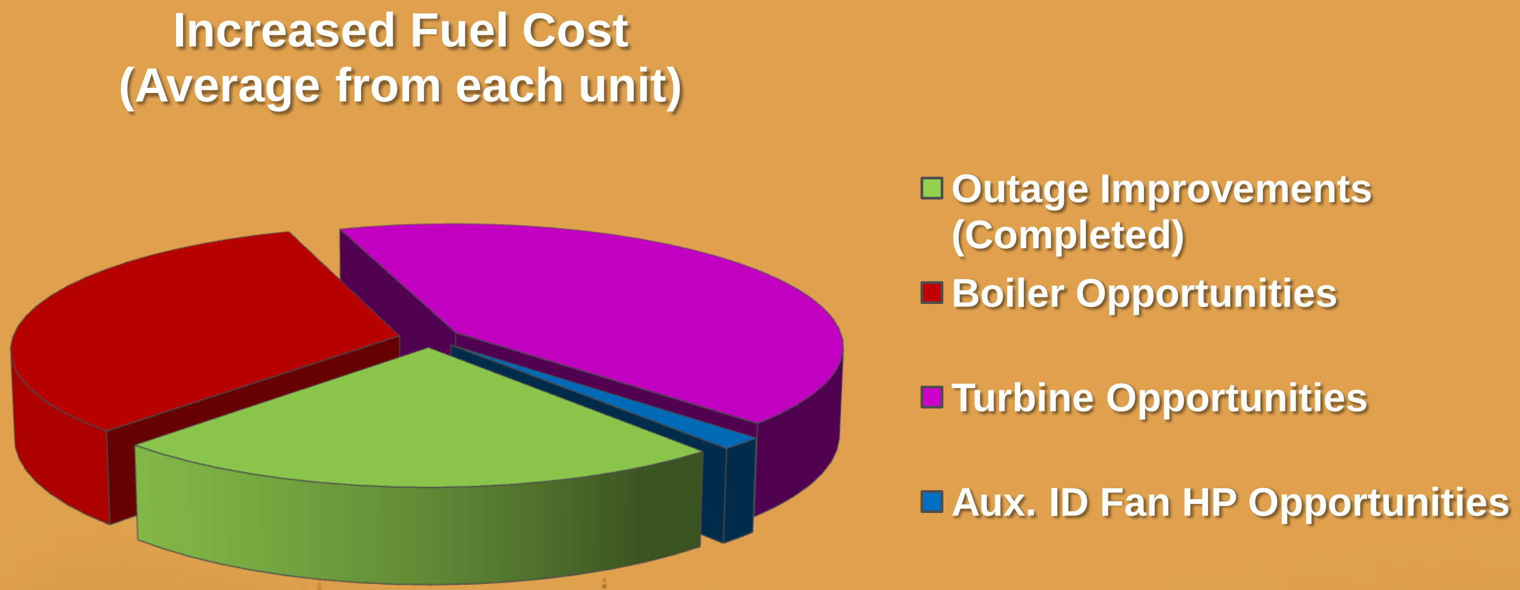
With average plant thermal efficiency measured at between 30 and 31%, this yields hundreds of kcals approximately (~1,000 – 2,000 Btu's) of heat rate improvement that were found available for improvement.

Average CO_2 Emissions Impact ("As Fired" Versus Design)

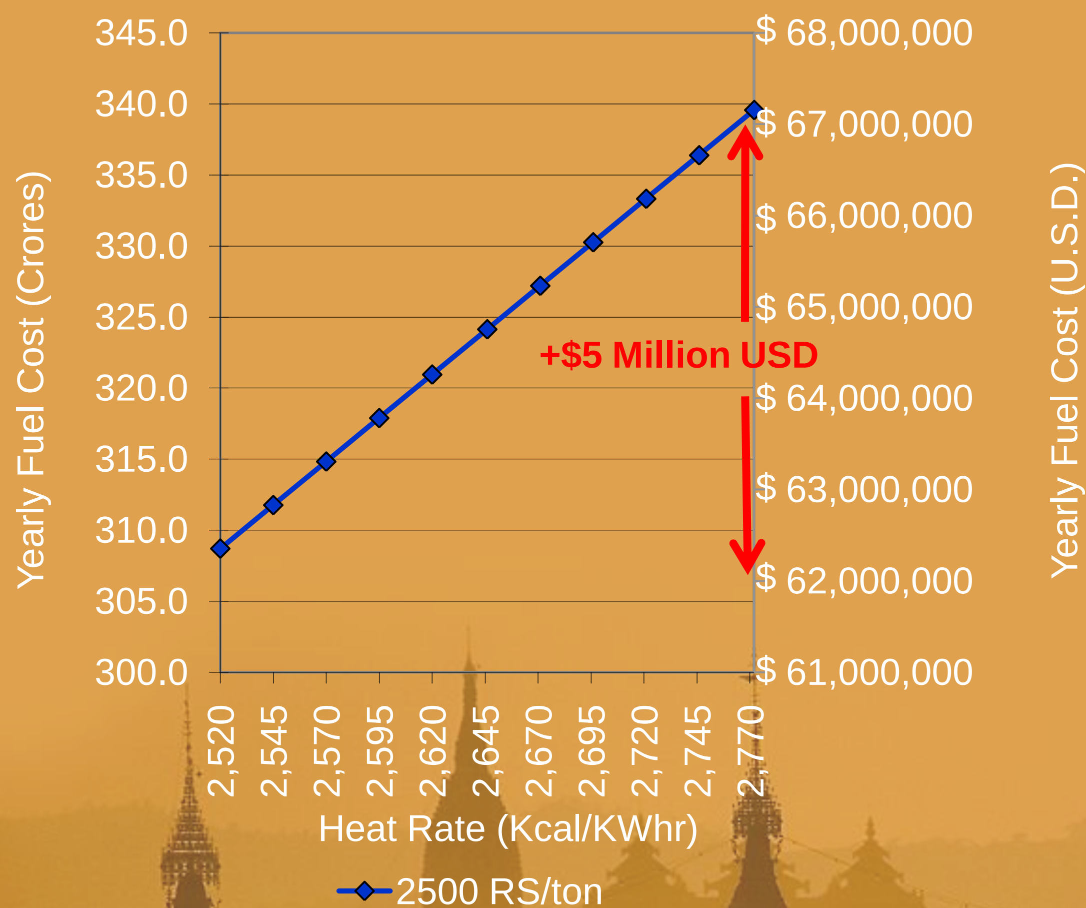


- 124,000 tonnes of CO_2 on the average could be reduced if both plants could operate closer to their design values.
- Assuming opportunity for improvement in all 6 units at each plant is the same, ~744,000 tonnes CO_2/year is potentially achievable at each plant.

Impacts of Performance on Fuel Cost



Heat Rate Impact on Fuel Cost Only (Average)



Parameter	Value
Load	210MW (Gross)
Operation	7,000 Hrs.
Fuel GCV	3,000kcal/kg
Coal Cost	2,500 Rs./Ton
Ash Content	50%

1 Crores = 200,000 U.S.D.

Twelve Key Points

1. Team training and commitment is essential
2. Installation of the testing ports and a performance program is essential
3. Excess O_2 at the furnace exit and economizer outlet must be optimized
4. Pulverized coal fineness must be optimized
5. Balance and supply adequate secondary air flow. This must be controlled with validated and proven total airflow metering devices within each of the main supply ducts.
6. Wind box to furnace differential must be optimum
7. Mill air to fuel ratios should be optimum and controlled
8. Fuel flow should be balanced to ±10% of the mean
9. Clean air velocities (fuel line transport energy) balanced within ±2%
10. Burner tolerances within ±¼ inch (6 mm)
11. Boiler efficiency and air in-leakage assessments are essential
12. Air in-leakage must be maintained at a minimum

Closing

- The results achieved have identified what is needed to improve the efficiency opportunities as well as improve the plants capacity and emission levels.
- These plants immediately began utilizing the protocol for plant wide improvements and trouble shooting efforts.
- Replicating efficiency improvement practices in all 6 units at each plant and realizing the full combustion optimization potential, substantial overall reduction of CO_2 emissions could be realized
- In addition to efficiency improvements achieved both plants, the testing demonstration was helpful in identifying how to operate close to or at design capacity . In India, this is most important !