



# Success stories: Efficiency Improvement in Power plants

Surendra Prasad  
AGM, CenPEEP/ NTPC

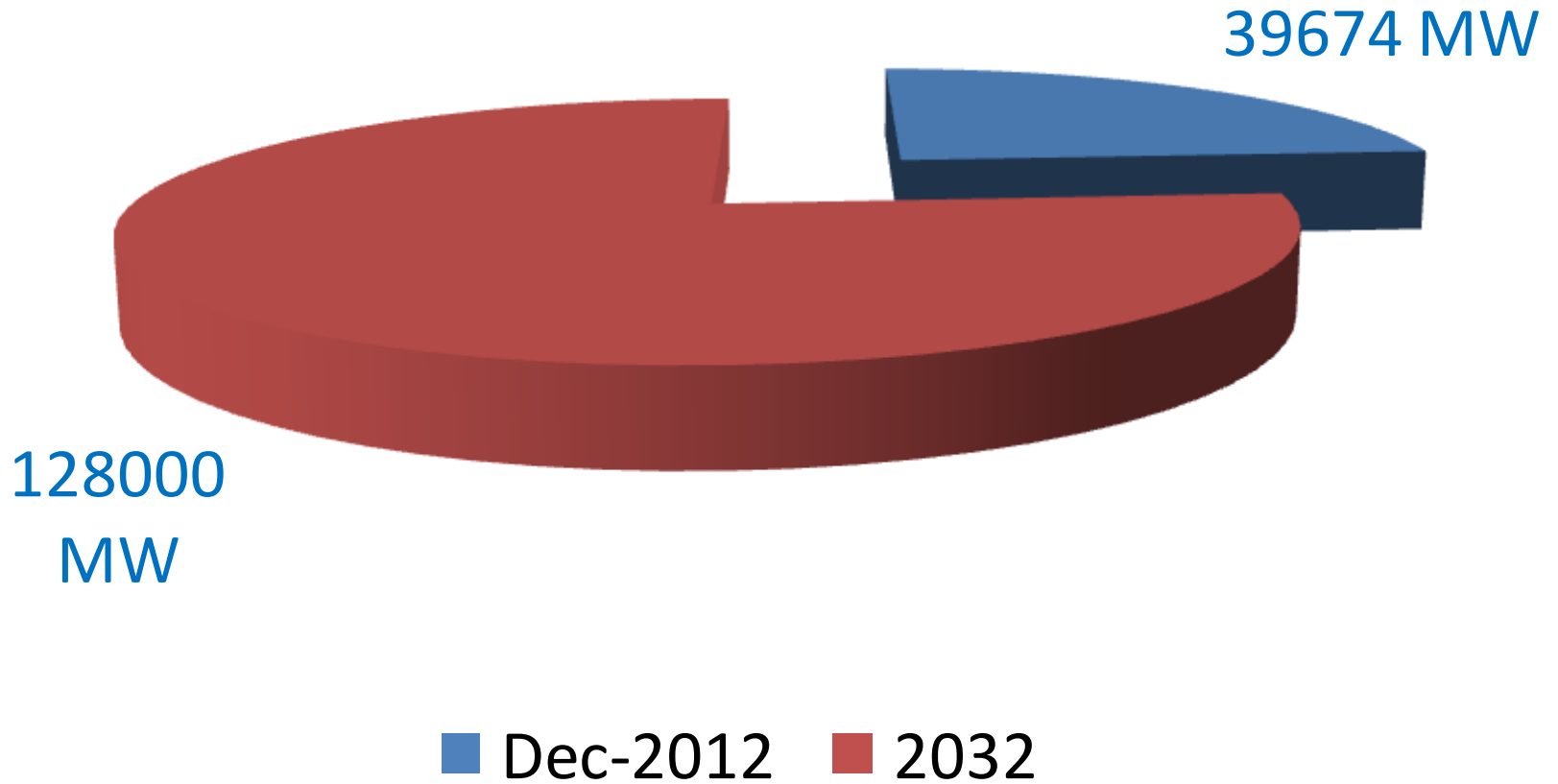
# Presentation Outline

- ❑ **Indian Power sector: Challenges**
- ❑ **NTPC Overview**
- ❑ **Strategies for Efficiency Improvement**
- ❑ **Systems, Technologies & Practices**
- ❑ **Success stories**
- ❑ **Conclusion**

# Indian Power Sector : Challenges

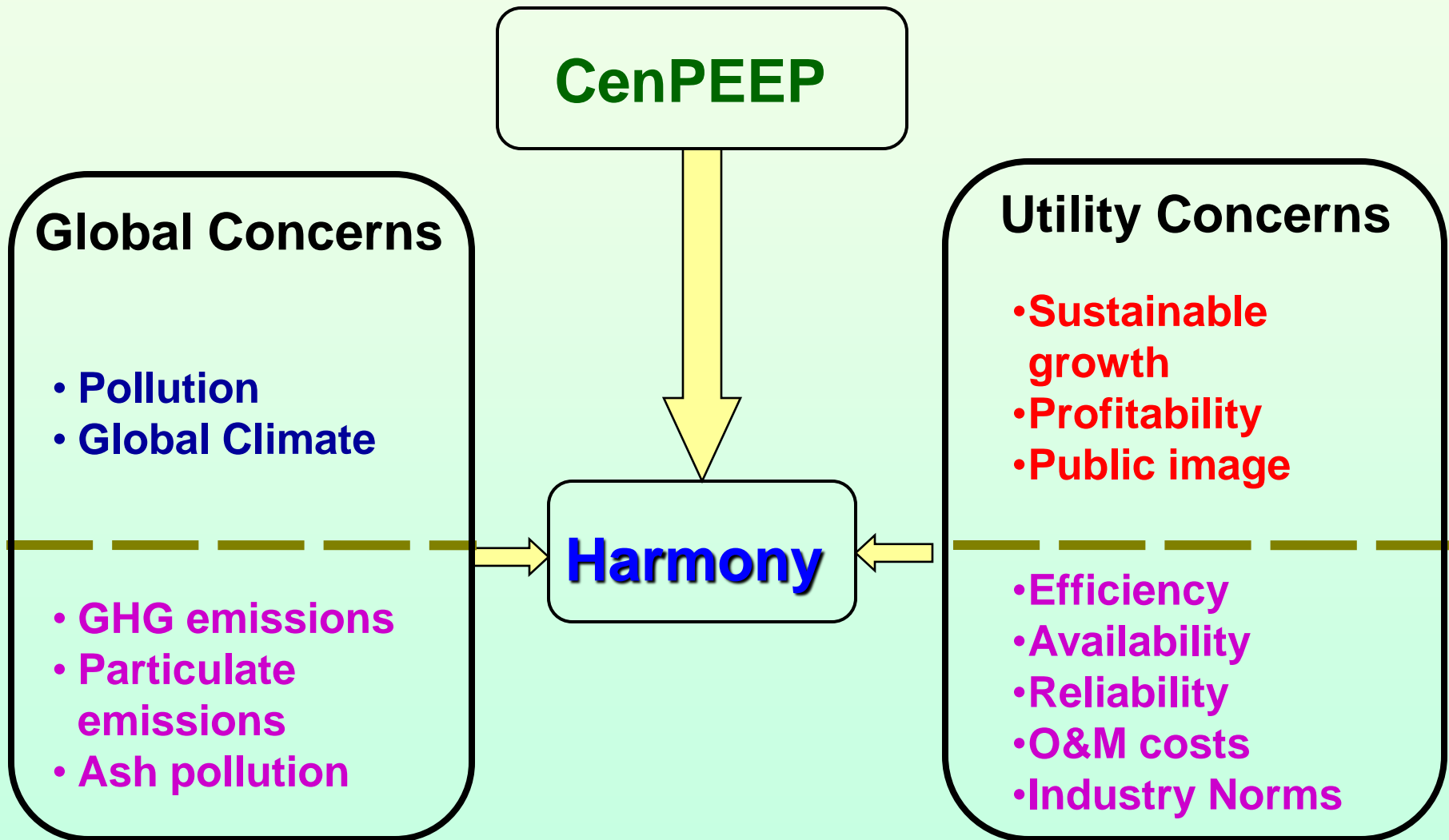
- Efficiency Improvement
- APC reduction
- GHG Reduction
- O&M cost reduction & Optimization
- Coal quality
- Service providers

# NTPC's Capacity Addition Plan



Aggressive Capacity Addition Plans

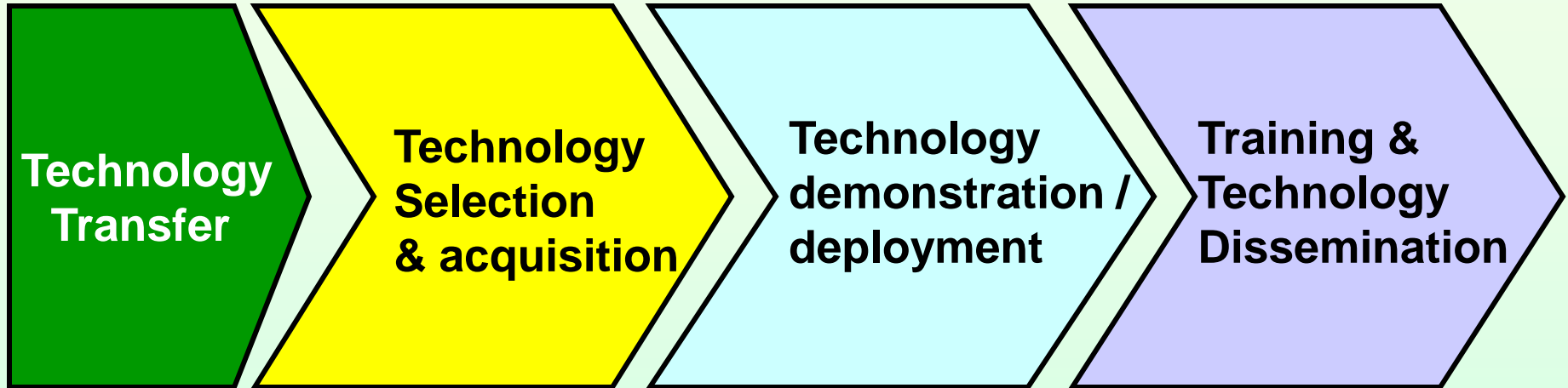
# Efficiency Improvement & GHG Reduction Program



**Win-Win Strategy**

# Methodology

## Approach



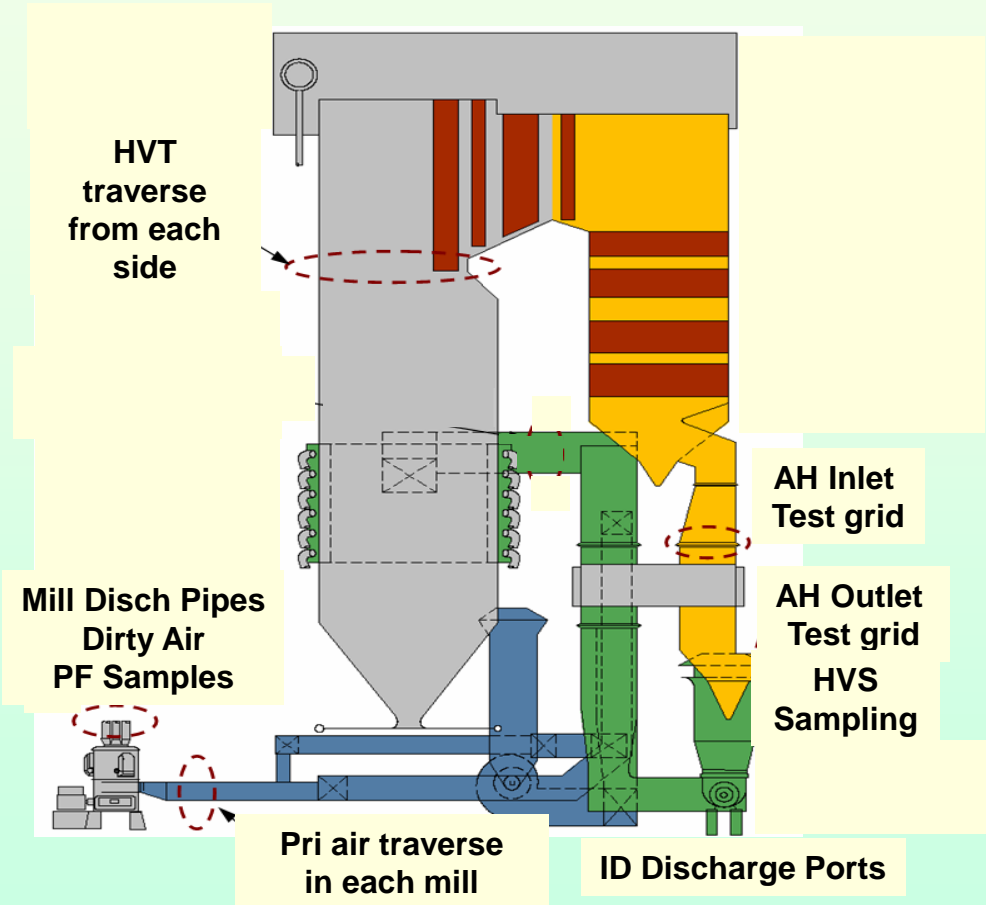
## Success factors

- **Demonstration**
- **Sustainability through systems, procedures & practices**
- **Institutionalization**
- **Thrust on low cost / high benefit technologies for sustainability**

# Boiler Performance Optimization

## Technology & Practices

- Air-fuel ratio test
- Iso-kinetic PF Sampler
- In Situ Fly Ash Sampler
- High Velocity Traverse (HVT)
- Grid Sampling
- Primary Air Flow Calibration
- Oxygen Mapping
- Furnace Temperature Mapping
- Development of ANN based optimization tools





# Turbine Performance Optimization

## FW Flow Measurement

- FW Flow Measurement using high Temp Ultrasonic probe
- Validation of FW Flow

## Cooling Tower Performance

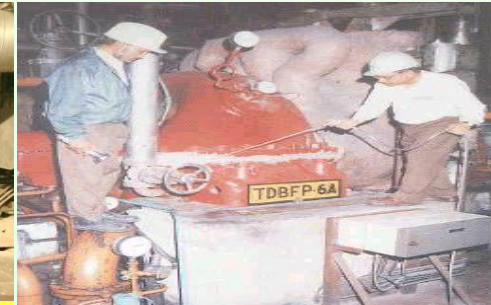
- CT single cell performance test
- Effect of L/G ratio on CT performance
- CW flow measurement
  - Ultrasonic flow meter
  - Three hole pitot tube

## Turbine Perf. Assessment

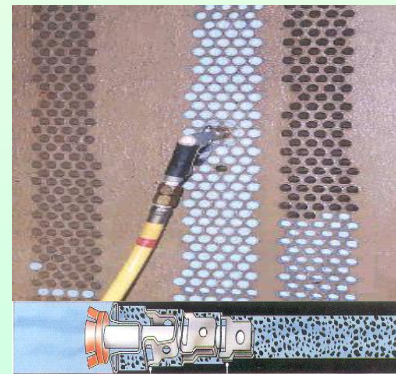
- Condenser performance
- Turbine cycle heat rate
- HP / IP Cylinder efficiency
- HP heaters performance



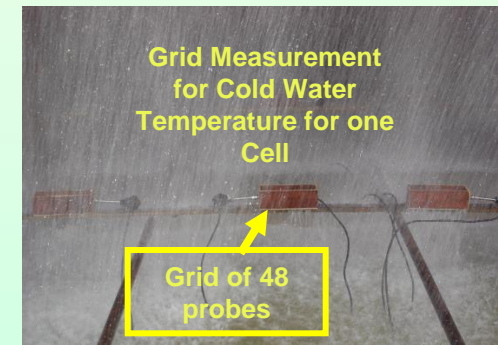
FW Flow Measurement



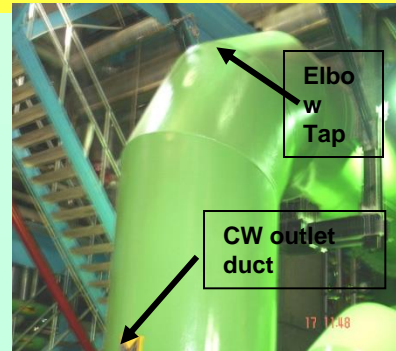
Helium Leak detection



Condenser Tube Cleaning



Cooling tower single cell testing



"Elbow Tap dp" for on-line CW Flow monitoring.



Turbine stud Opening



# **Strategies for Efficiency improvement**

- **Performance Tracking**
- **Performance Assessment & analysis**
- **Efficiency GAP Identification & Action planning**
- **Optimization**
- **Integration with Maintenance strategies**
- **Sustainability : Institutionalization & Implementation**

# Performance Pyramid

Focus on each  
sub-system &  
plant  
equipment

Periodic Audits  
to identify  
areas of  
degradation &  
gaps

NHR

Availability

Boiler Turbine

Air Pre Htrs HP& IP Turbine

Boiler Press parts BFP & HPH/ LPHs

Mills & Burners Condenser & CW System

Coal handling system Gen; X-mer & switchyard

Human Resource

# Energy Efficiency Management System

Accurate Gap  
Assessment &  
Analysis

Development,  
Implementation  
of Action Plans

Capability  
Building

Performance  
Improvement  
Projects (PIPs)

R & M  
Retrofits

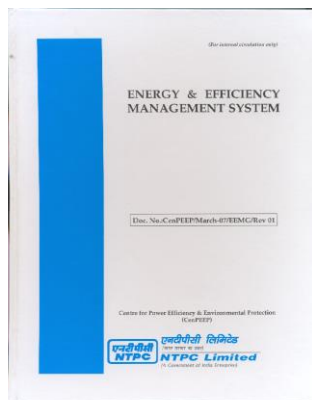


**Focus on degradations in Individual Equipment**

# Energy & Efficiency Management System (EEMS)



Release of EEMS document



Equipment Efficiency Computation Program

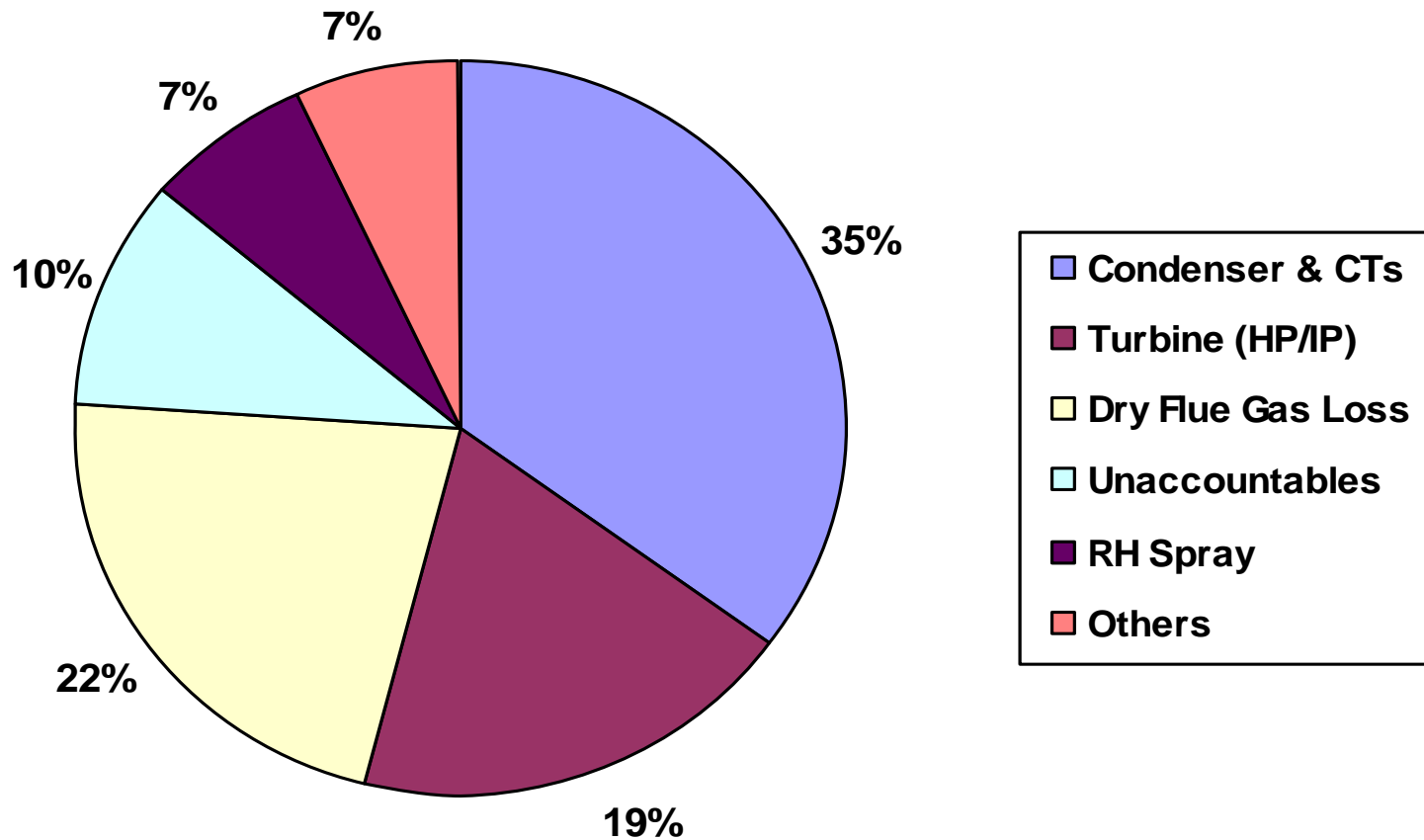
## Development & Implementation of EEMS

- Identification of Heat Rate gaps through monthly performance tests
- Trending performance indices & analysis of equipment degradations
- Development of Unit specific HR recovery action plans
- Restoration of equipment performance during overhauls
- Skill / knowledge enhancement through Dissemination workshops

**Customized EEMS Document prepared based on learning's at CenPEEP and 'Heat rate Improvement Guidelines' issued earlier**

# Typical HR Performance Gaps

## Major Heat Rate Loss Areas



***What can not be measured can not be saved!***

# Major Losses : Condenser

## Major Reasons

- Dirty tubes/air ingress:
- Choking/fouling of condenser tubes
- Debris / Hyacinth growth
- Air ingress
- Ingress of ash / siliceous material
- Effectiveness of OLTCs
- High condenser loading
- Low CW flow

## Strategies

- Accurate analysis – data validation, trending & analysis
- Absolute pressure transmitter & CW flow measurement
- Action Plan : condenser tube cleaning / replacement
- OLTCs / Debris filter:
- Practice of opportunity cleaning
- Identification and attending air ingress point
- Passing of high energy drains
- Identification of engineering issues
- Chemical treatment of CW



# Major Losses: DFG

## Major Reasons

- AH performance deterioration
- Seal (circumferential) leakages
- Gaps between baskets, & diaphragms
- Baskets fouling
- Air ingress in Boiler / pent house / ducts
- High boiler loading
- Soot blowing in-effectiveness
- Engineering issues (design, modifications)

## Strategies

- Accurate measurement – online & offline data, trending & up-gradation
- Action Plan & Restoration: Boiler & Air Pre heater
- Focus on preparedness: OPI
- Component upgrades : Air preheater & Pulverizer
- Identification of engineering issues
- Operational optimization

# O&M Practices Adopted

## Measurements for better control of combustion

- *Relocation of T/Cs for Air & Flue Gas Temp Measurement*
- *Additional Zirconia probes in Gas ducts*
- *PF sampling from individual coal pipes*
- *Grid Sampling in Gas ducts using portable analyzers*

## Mills

- *Dirty air velocity Tests*
- *Isokinetic coal sampling*
- *Assessment of PF balance amongst burners*

## Boiler & Air Heaters

- *Performance assessment, trending & analysis*
- *Periodic AH Basket Cleaning & Replacement*
- *Air Ingress quantification by Oxygen traverse in Gas ducts*
- *Repair of Ducts & Replacement of Expansion joints*
- *Parametric optimization*
- *Tracking of differential pressure across APH*

# O&M Practices Adopted

## Condenser

- Periodic & Opportunity cleaning with Water powered cleaners
- Installation of absolute condenser pressure transmitter
- Comparison with expected condenser pressure
- Condenser air flow, depression & differential pressure tracking
- High Energy drain valve passing

## Cooling Tower

- Introduction of CW Flow measurement technique
- Calculation of CT Capability instead of effectiveness
- CT capability test during July-Sept Period
- Cleaning of fills / cold basin
- Thrust on Chlorine dosing

## Turbine:

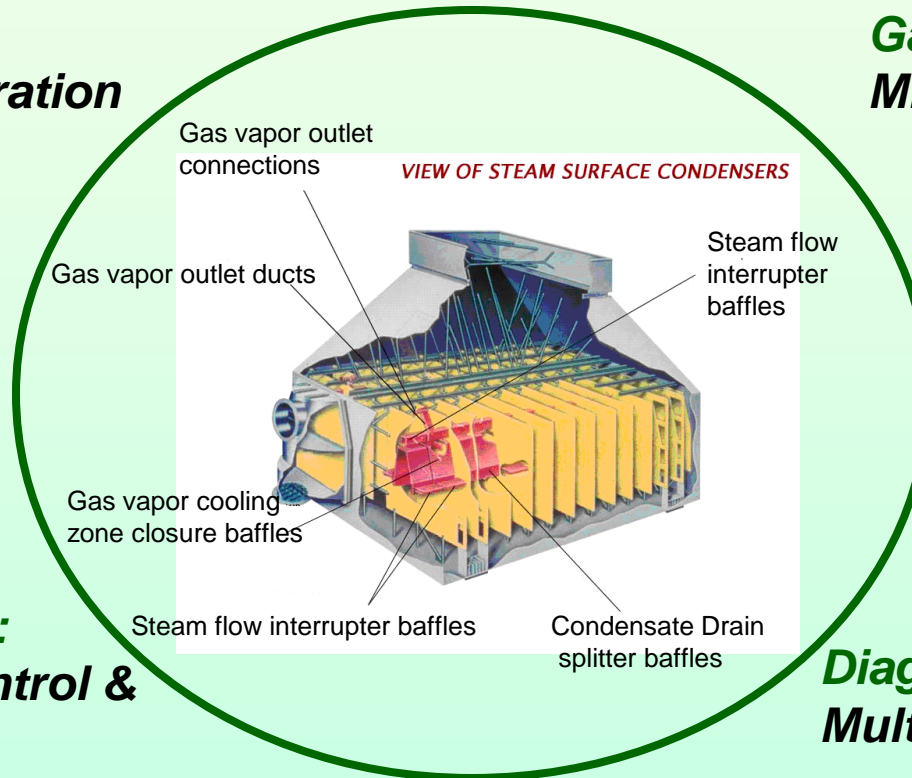
- HP/IP Efficiency Offline Testing at VWO
- Pressure leg correction for accurate test assessment.
- Thrust on seal repair/replacement
- GTCHR Testing with use of Total Feed water flow
- Introduction of TD BFP Loss assessment

# Multiple Technology approach for Improvement : Condenser

**Reliability :**  
**Failure mode analysis**

**Risk Analysis :**  
**Impact on generation**

**Gap Analysis:**  
**Mitigation strategies**



**Math Modelling :**  
**Parameter evaluation**

**Diagnostics:**  
**Multiple technology usage**

**SMART Catch :**  
**Proactive approach**

**O&M approach:**  
**Monitoring, control &  
optimization**

**Multiple Technology Approach for performance improvement**

# Case Study on Condenser Loss

## Case: Observations/Problems

Both vacuum pump was running

Air suction temp depression Left/Right : 4/13 degree C

Variation of Condenser vacuum due to air ingress/dirty tube was 44 mm Hg.

On the basis of primary investigation, condenser air ingress test using Helium leak detector, acoustics and IRT was done by CenPEEP.

## Findings:

During above test a hole (2"x 1") of size in CRH strainer drain to HP Flash box was found

# Case Study on Condenser Loss



**Hole in the CRH strainer drain line**



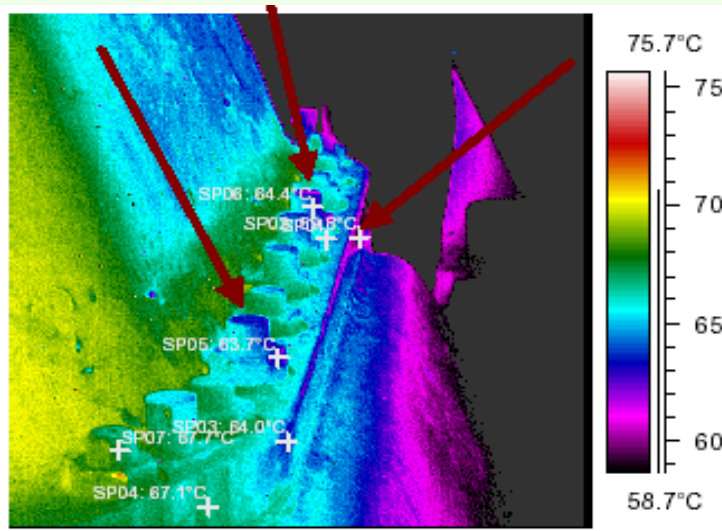
**Hole fixed up using clamp**

## **Benefits of Testing:**

1. Improvement in condenser vacuum by 16 mm Hg
  2. Stoppage of one vacuum pump there by reducing in APC and increased operational reliability
1. Unit Heat rate improvement : 32 kcal / kWh

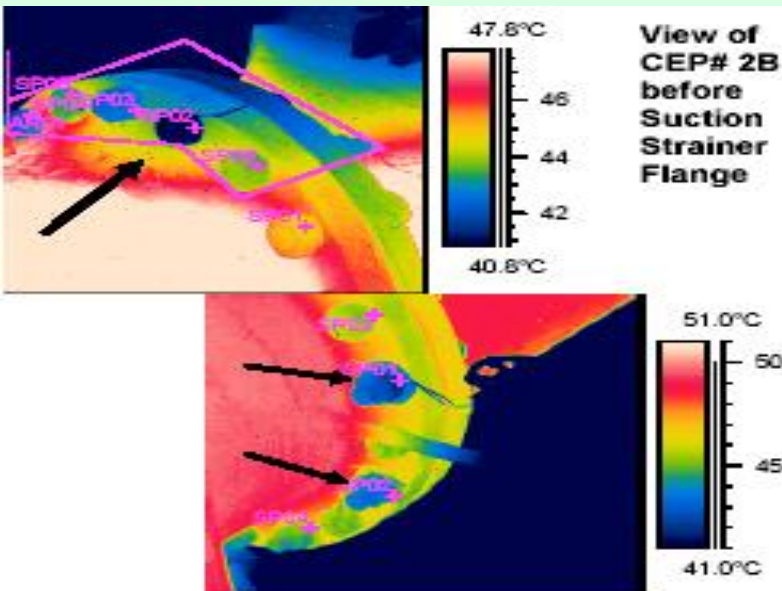


# Case Study on Condenser



Air in leak observed from LPT parting plane surface & Bolt edges ( Shown by arrow)  
Temperature difference of appx. 6-7 degrees was observed in the surface of parting plane.  
Devecon putty was applied to arrest the air in leakage from parting plane.

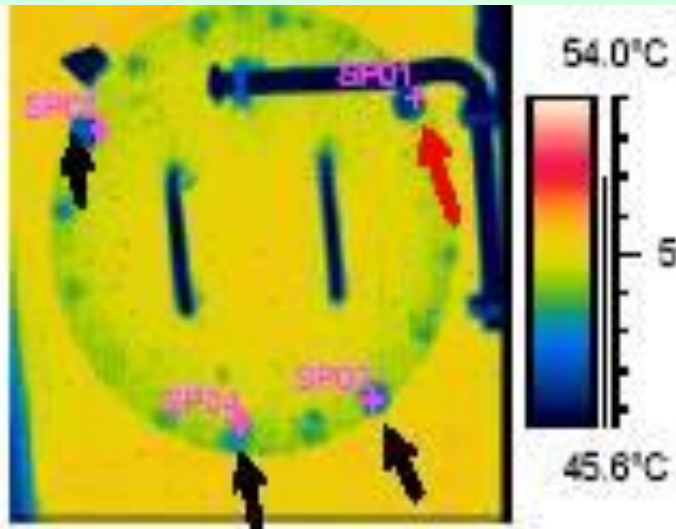
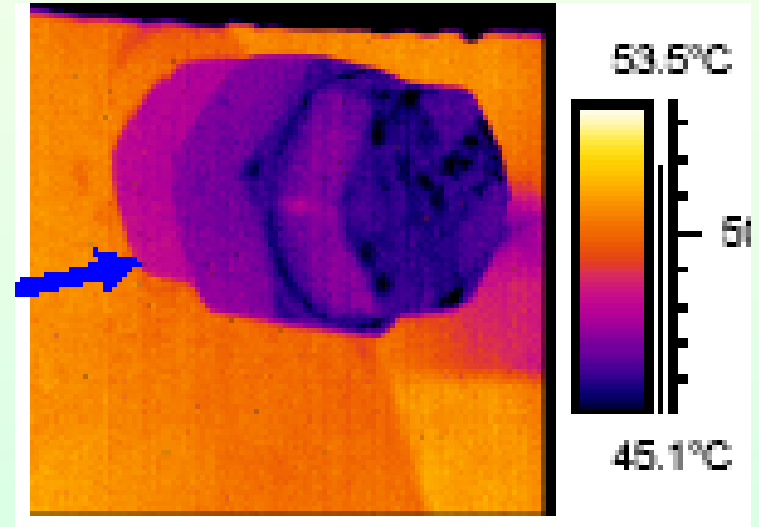
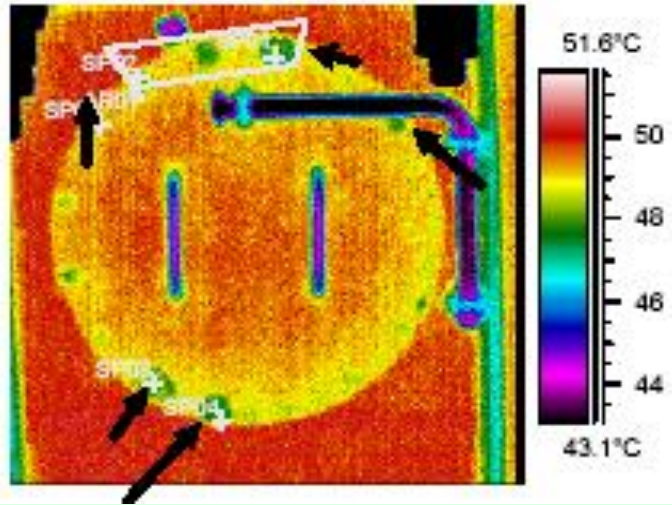
**Improvement in MW**



**CEP 2B** Suction strainer flange bolts showed bolts looseness & was recommended for re-tightening.

**DO level reduced from 110 PPb to 10-15 PPb**

# Case Study on Condenser

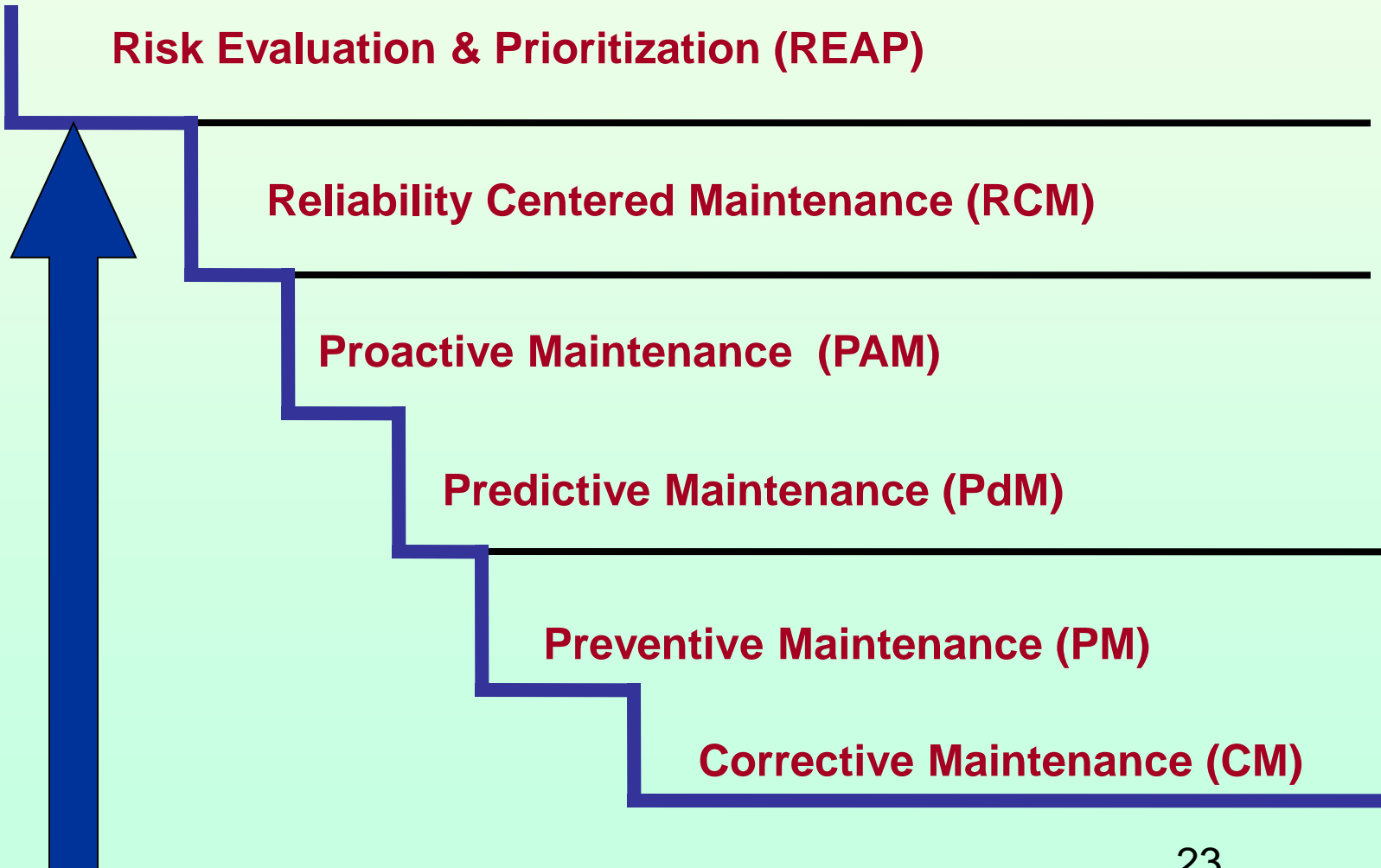


10 no. bolts of Hotwell (A & B) were found loose having having air ingress from them to the system. All the bolts were retightened. **Improvement in vacuum of 5-7 mmHG**

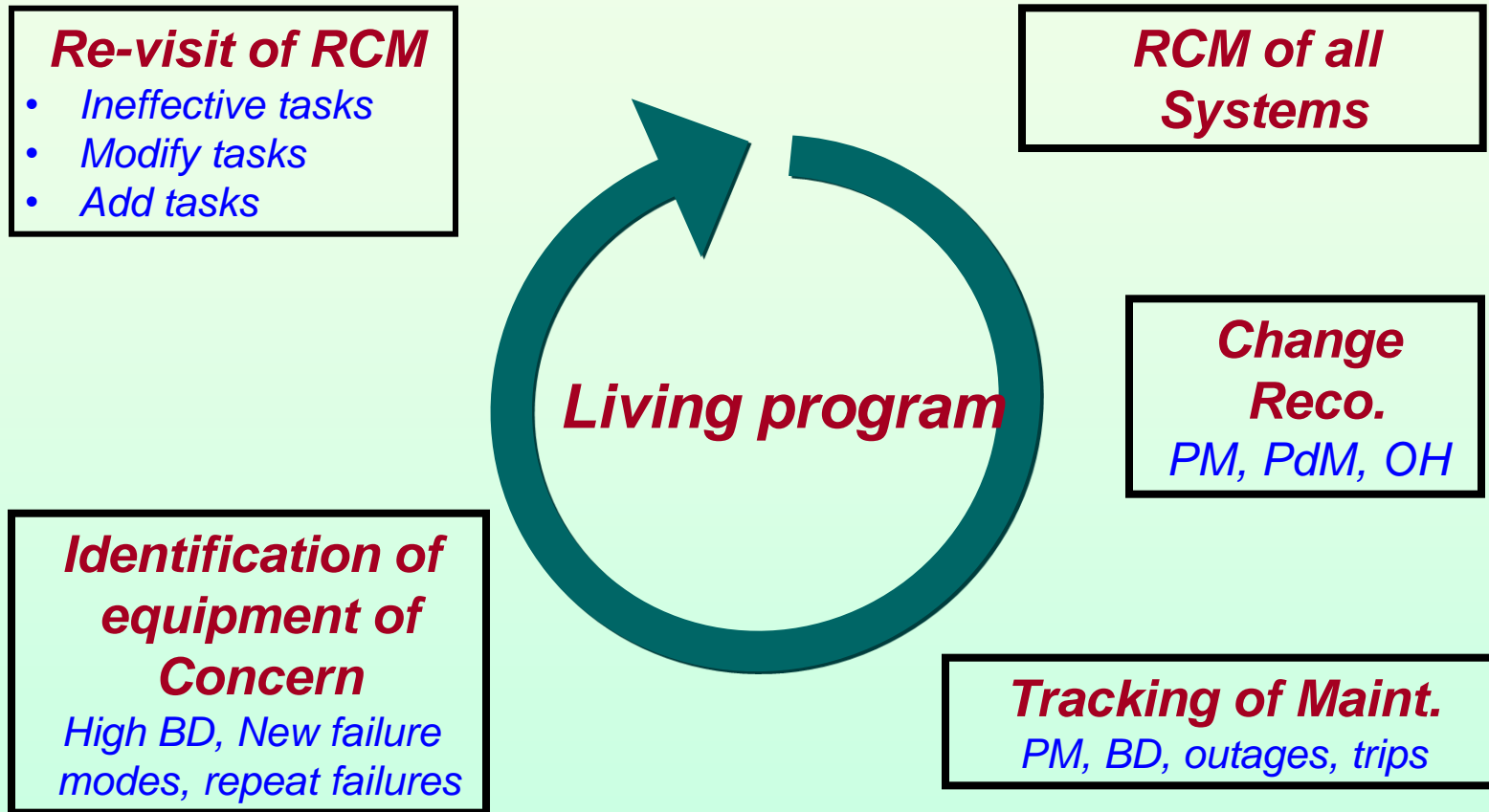


# Maintenance Strategies

## Road map : *Knowledge Based Maintenance*



# Reliability Centered Maintenance

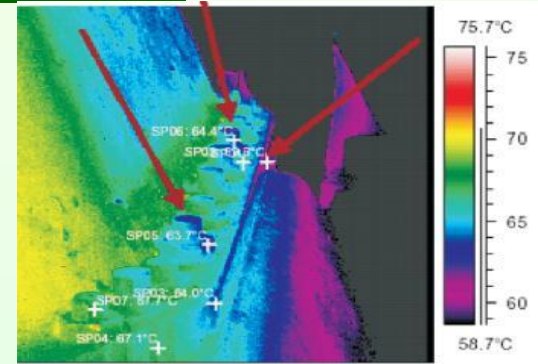


***Imbibing RCM: Tool for maintenance rationalization and sustaining functional performance of equipment & systems***

# Monitoring & Diagnostics

## Infrared Thermography - New Applications

- Air-in-leak in turbine cycle, condenser, manholes, flange joints, etc.
- Fast method for location identification



Air-in-leak at LPT by IRT

## Acoustics - New Applications

- Condenser tube leak detection by acoustics
- Faster and accurate method, avoided forced outages



Condenser Tube Leak Detection

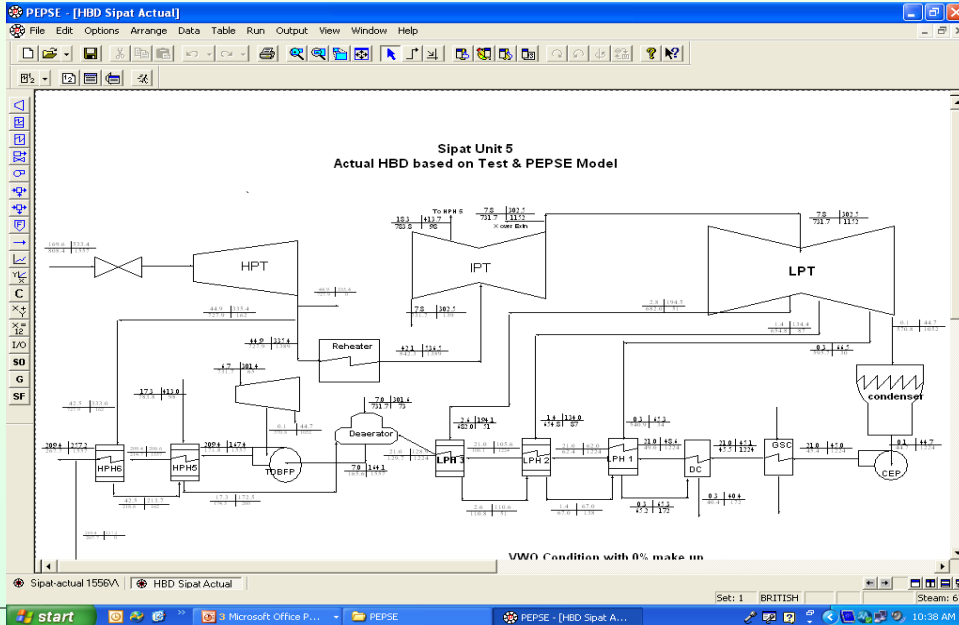
## Video Scope

- Internal inspection without opening a machine (*like HT motors, turbine extraction lines*)
- Facilitates inspection and reduces human induced faults



Condition of varnish and air-gap in HT motor

# Thermal Cycle Audit



## Heat Rate & Capacity Deviations

### Methodology

- Cycle Modeling using PEPSE
- Validation of measurements
- Maximum Capacity Test (VWO)
- Assessment of Eff. deterioration
- MW check & Reconciliation of data
- Heat rate & MW deviations

### Benefits

- Accurate performance analysis
- Quantification of degradations
- Validation of Process parameters
- Identification of Component level degradations

Description	HBD	Test	MW dev.	HR dev
MW	529.8	511.7	18.1	---
HPT Eff %	93.10	89.02	6.4	14
IPT Eff %	94.33	90.25	4.8	17
Cond Prsr.	0.1047	0.0963	-1.5	-6
MS temp C	537	533.4	-0.3	2
RH temp C	537	536.5	0.5	0.0
HP Heaters	255.8	257.2	1.2	-1.0



# SMART Catch

## Back Ground

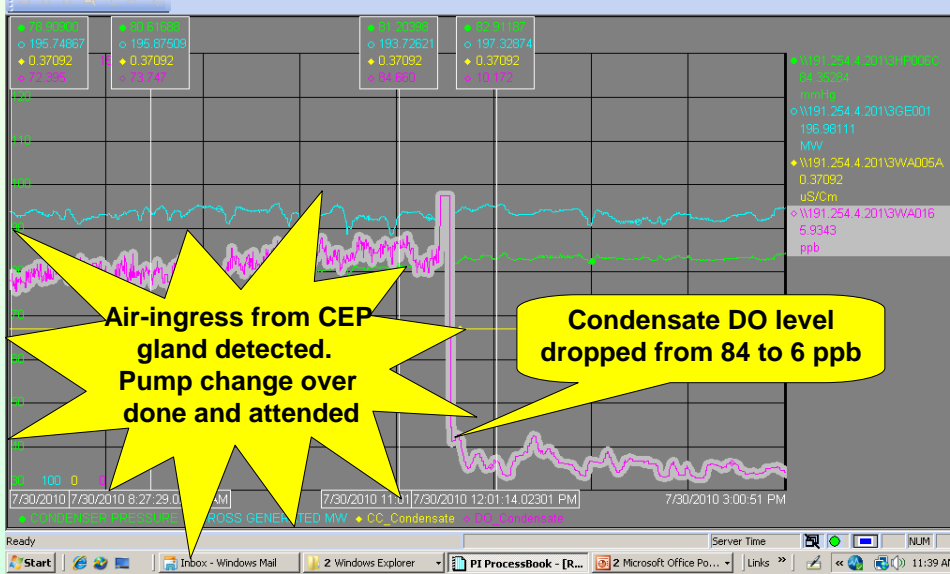
- ✓ Ageing fleet
- ✓ Reduction in O&M cost
- ✓ Optimization of plant processes
- ✓ Limited experts in specific areas
- ✓ Reduction in GHG emissions
- ✓ De- regulation and Global competition
- ✓ Rapid growth in capacity, across the country
- ✓ Best practices get restricted to a Station

## Objective

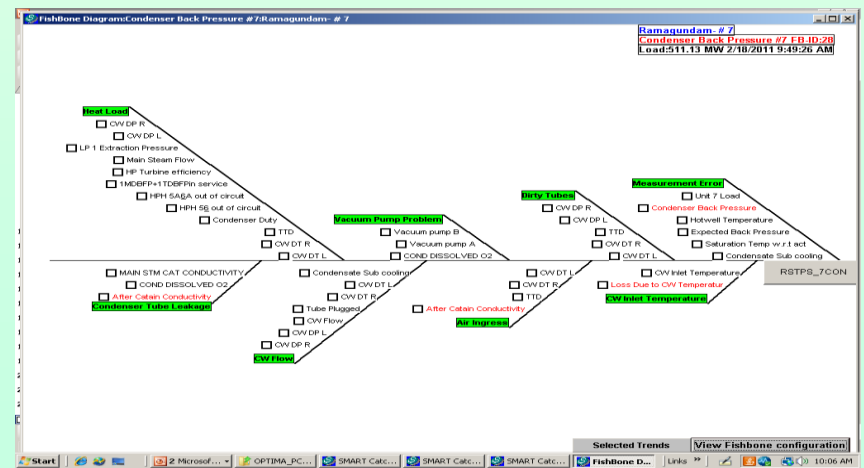
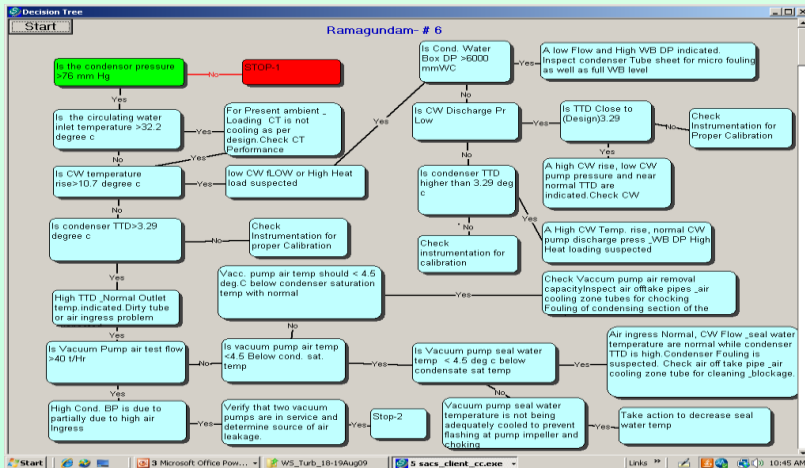
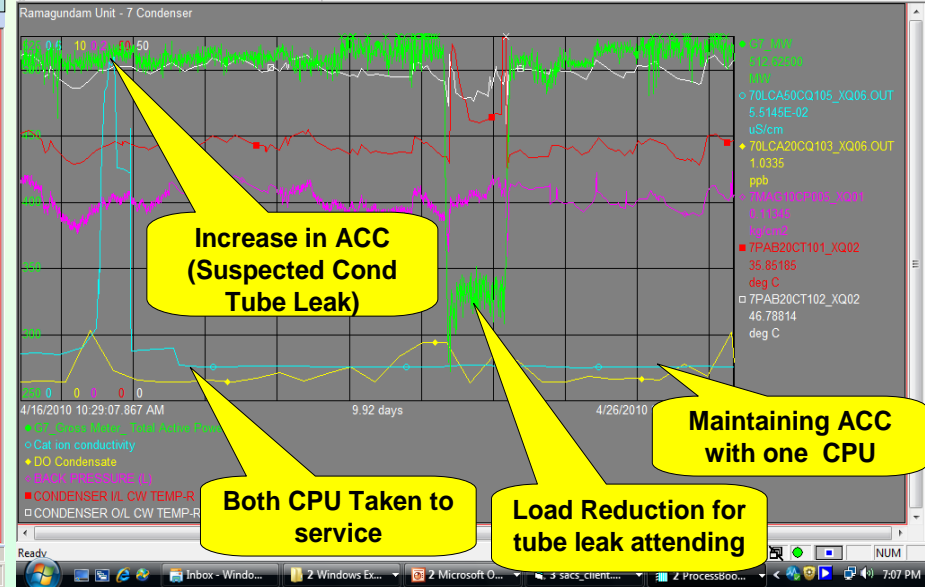
- ✓ To bring the real time data to
- ✓ Remote Places (Corporate Centre & Regional Centre)
- ✓ 24x7 Access to Specialized
- ✓ Domain Knowledge
- ✓ Deployment of State-of-the-art
- ✓ Software & Diagnostic Tools
- ✓ Advisories to Plant personnel
- ✓ Creation of “Knowledge Repositories.”
- ✓ Move Data, Not People
- ✓ Single point OEM interface

# SMART Catch: Proactive Approach

## Ramagundam U#3 Condenser Air Ingress



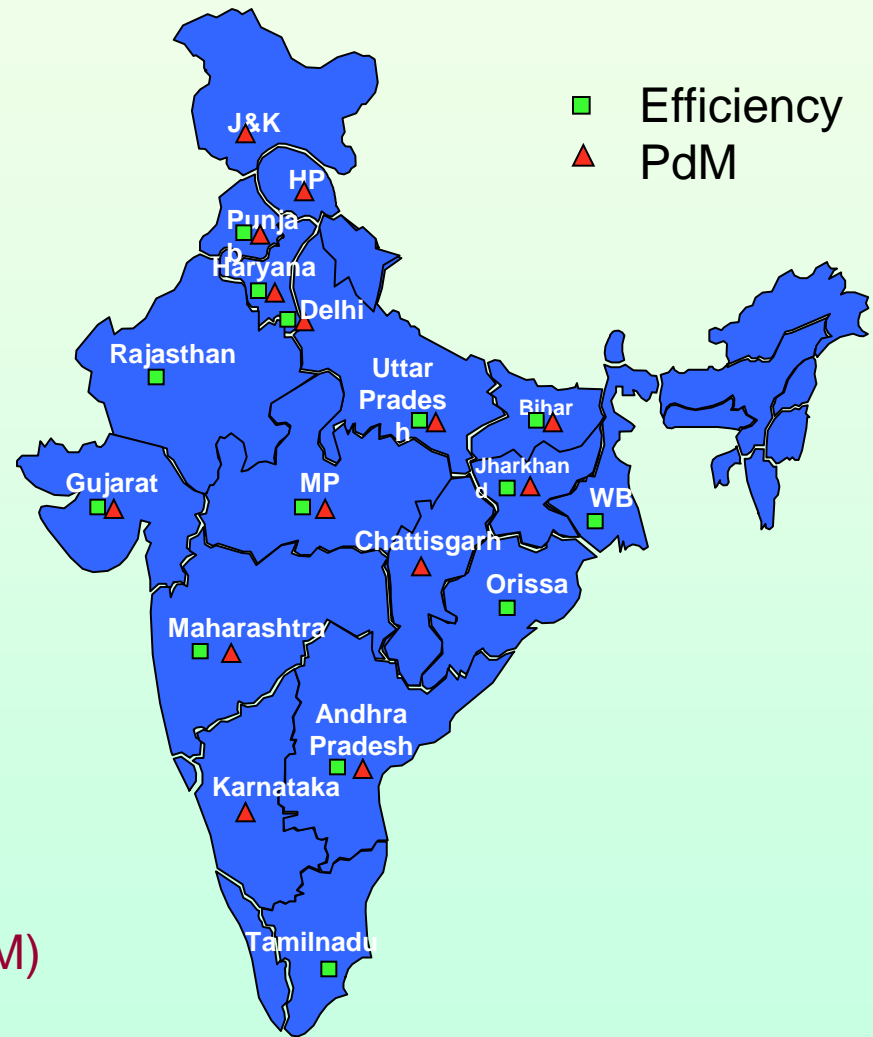
## Ramagundam U#7 Condenser Tube leakage



Capturing experiential learning & initiating advisories for operator guidance

# Pan-Indian Demonstration & Dissemination

- Comprehensive Performance assessment : Demo & Hands on training in 7 state utilities
- Performance assessment & workshops in 14 states utilities
- PdM demo in 14 states



## Utility Support Mechanisms

- Trainings at PMI / SEB door steps
- Partnership in Excellence (PIE)
- Asia Pacific Partnership (APP)
- Customer Relationship Mgmt (CRM)
- Consultancy

# CenPEEP Role in Asia Pacific Partnership (APP) Program



## Support to ‘Power Generation & Transmission Task Force’ Activities

- Sustainable ‘Efficiency Improvement’ at 3 state utilities (Punjab, West Bengal, Tamil Nadu)
  - Workshops & Walk down visits with US Experts
  - Pre Outage Assessment Tests & support during overhauls
  - Post Outage tests on Boiler & Air heaters with M/S Storm and Turbine tests by CenPEEP – Hands on Training to station engineers
- Study Visits to U.S. utilities



Workshops



Field Tests

### Improvement Potential (kcal/kWh)

Area	Ropar	Kolaghat	Tuticorin
Boiler	105	150	100
Turbine	137	125	317

# Development of Service Providers

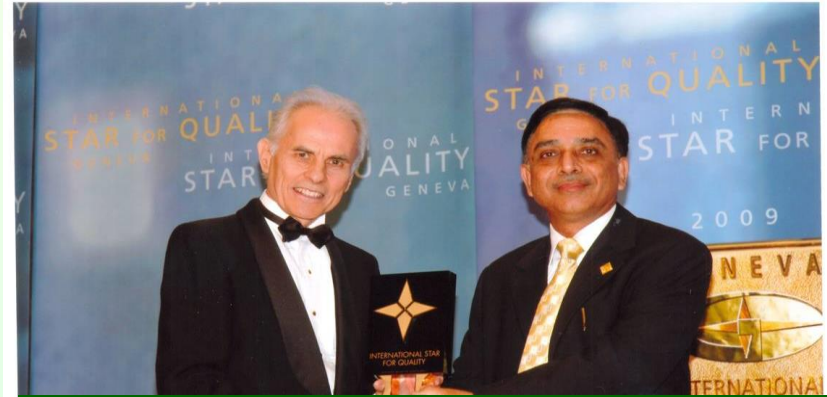
## Some examples:

- Condenser tube cleaning (CONCO system)
- Condenser air-in-leak detection (helium leak detection)
- Eddy current turbine stud heating for stud removal
- Infrared Thermography as diagnostics – ‘coal yard to switchyard’; earlier limited to electrical;
- Acoustics as diagnostics: introduced for the first time
- Dirty Pitot for air-fuel ratio optimization
- Cooling Tower capability test (earlier limited to effectiveness)
- Service provider role: extended to optimization & performance test

# International / National Recognitions



CTI's World Climate Technology Award  
by CTI/IEA-Paris (2002)



International Gold Star for Quality Award  
by BID International- Madrid (2009)



USEPA Climate Protection Award  
(2003 )



India Power Award by Council of  
Power Utilities, India (2008)



# In Conclusion

- **Skills / awareness** for performance improvement
- **Dedicated groups** for Energy Efficiency & Reliability at Stations
- **Comprehensive plans** for performance enhancement
- **Sustainability :** Institutionalization & Implementation

- **Ageing Fleets**
  - Requirement of high investments
  - Dependence on OEM Suppliers
  - OEM focus on New capacity
- **Reduced operating margins**
- **Availability of Expert Service Providers**
- **Financing of Efficiency Improvement projects**

*Performance Improvement is a journey, not a destination*





***Together we work for a greener world***

***Thank You***