# Strategy for

## Improving Net Heat Rate & Optimisation

***An Essential Tool for Performance Improvement***

*29th November'2022*

# Presentation

- Energy Efficiency – Overview
- Heat Rate Deviation – Cause & Effect
- System Approach for Implementation
- Approach for APC Optimisation
- Improvement through O&M Practices
- New Technology Interventions
- Conclusion

# Energy Efficiency - Overview

- Energy efficiency is the driver to achieve GHG/CO2 emissions reduction
- Performance improvement of power plant is the key to meet the challenges in the changed business scenario, new environment regulation, regulatory & PAT regime
- Conservation of Natural Resources for Future Needs
- Utilities need to:
    - Do prioritization & develop cost effective solutions to correct degradation in thermal / equipment performance & auxiliary power
    - Plan recovery of losses and sustenance of performance.

# PAT: A Paradigm Shift

- Unique scheme – transformation from voluntary reduction program to mandatory regime
- Focus shift from Gross Heat Rate (GHR) & APC to Net Heat Rate (NHR)
- Focus on planning and timely implementation of schemes/action plans for achieving PAT targets.
- Focus on R&M : Renovation and modernization with emphasis on replacement with efficient components.
- PAT has created opportunity to meet requirement of continuous improvement to maintain high efficiency year around.
- Equal emphasis on efficiency/loading factor and avoiding unit trippings

**Reliability is the platform to sustain high efficiency**

# 500MW Unit Typical Per Year Cost Implication of 10 kcal/kWh HR Deviation

| Impact of HR Deviation | Coal Saving Per Year | Cost Saving Per Year |
|---|---|---|
| 10 kcal/kWh | 7695 Tons | Rs. 3.27 Cr |

***'What can not be measured can not be saved'***

***Assumption : GCV 3700 kcal/kg , Coal Cost Rs 4250 per Ton, PLF 65%,***

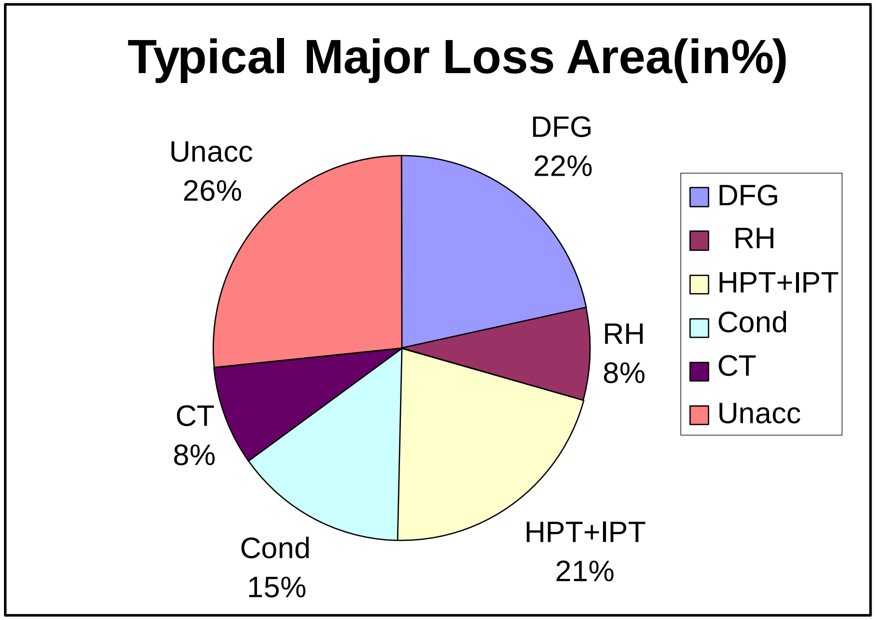
# Energy Efficiency – Typical example of Financial Impact

*Financial Implication ( yearly) of Improvements*
*for 200MW & 500 MW Units*

| Items | 200 mw Unit | 500 mw unit |
|---|---|---|
| 10 kcal GHR Improvement | Rs 1.7 Cr | Rs 4.06 Cr |
| 0.1 % APC | Rs 0.4 Cr | Rs 1.1 Cr |
| 10 Kcal NHR Imp | Rs 1.48 Cr | Rs 3.8 Cr |

# Typical Example: Heat Rate Gaps Mapping in Power Utilities

## Heat Rate Gaps




1. **High Loss category**
   - Condenser (15 %)
   - Dry Flue Gas Loss (22%)
   - HP / IP Turbine(21%)
   - Unaccountable (LPT Efficiency, Hi Energy drain passing, Insulation loss, etc) (26%)

2. **Medium Loss category**
   - RH Spray (8%)
   - Cooling Tower (8 %)

# Heat Rate Deviation – Cause & Effect

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## Heat Rate Deviation System- Cause & Effect

- Heat rate deviation system is an important component of HR Improvement Program.
- Success of the HR deviation program depends upon the accuracy with which HEAT RATE and parameters affecting HR DEVIATION are measured.
- Heat rate deviation components enable us to focus on areas of heat losses and action plan made to serve priority areas.
- Difference between expected HR and operating HR should be fully accountable.

# Heat Rate Deviation System

- High Unaccounted component of deviation can be due to poor data base.
- IMPROVING ACCURACY of UNIT HR requires intensive efforts
- However, accuracy of parameters affecting heat rate can be improved at nominal cost.
- Operation of unit at optimum parameters would result in achieving best from unit.

# Heat Rate Deviation - Controllable Parameters

- List of parameters to be monitored , tracked for HR Deviation has been Standardized /identified for most cycles.
- These parameters are monitored very accurately during PG & routine tests.
- Upgradation of station instruments used for monitoring these parameters essential.
- This requirement has been confirmed based on recent testing done at various stations.

# Controllable Parameters

- Maximum heat rate deviation could be on account of degradation of vacuum.
- UNDER WORST condition, back pressure would affect unit output as well.
- Deviation on account of HPT, IPT & LPT efficiency goes unnoticed due to lack of feedback.
- Auxiliary power consumption has a trade off, however, 2nd highest rank.

# Effect of Critical Parameters

| *Parameter* | *Deviation* | *Effect on Heat Rate* |
|---|---|---|
| Main Seam Temp. | -5°C | +2.3 kcal/kWh |
| Main Steam Press. | -1 $Kg/cm^2$ | +1 kcal/kWh |
| Reheat Temperature | -5°C | +2.3 kcal/kWh |
| Reheat Spray | +1%(MS Flow) | +3.0 kcal/kWh |
| Condenser Back Press | +1 mmHg(a) | +2.0 kcal/kWh |
| HPT Efficiency | - 1% | +4 kcal/kWh |
| IPT Efficiency | - 1% | +3 kcal/kWh |
| Excess O2 | +1% | +7.2 kcal/kWh |
| Flue Gas Temperature | +5°C | +4.6 kcal/kWh |
| DM Make-up | +1% | +17 kcal/kWh |

LPT Efficiency Impact – 0.5% of GTCHR for 1% Deviation

# System Approach for Implementation

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# Systems Approach for Efficiency & Reliability

- **Focus on Systems & procedure for good Operation & Maintenance practices**
- **Following Enablers are to be institutionalised**
  - Energy Efficiency Management System (EEMS)
  - Reliability & Maintenance Management System
  - Outage Management & Planning System
  - Skill development & training
  - Documentation & guidelines & awareness program
  - Advanced tools, technologies & practices , systems
    - Simulation & modelling tools
    - AI Based Optimisation and Diagnostic Tools
    - Analytical Tools for Flexible Operation

***Systemic approach is essential for continual improvements***

# Systematic Approach

Systems for sustained improvement in efficiency and reliability

**Energy & Efficiency Management System (EEMS)**

**Accurate Gap Assessment & Analysis**

**Skill & Awareness**

**Development of Action plans**

**R&M Retrofits**

**Planning & Implementation**

# Sub-System Approach:
## Simplified Performance Testing

***Approach is to introduce user friendly systems,***

***demonstration, finalization of Procedures / Guidelines***

***& dissemination to all***

***( like Air Preheater, Mill's, HP Heater, BFP to recover losses )***

***'Whatever is convenient, will only be replicated'***

# Reliability Centered Maintenance (RCM)

**Re-visit of RCM**
*Modify tasks, frequency, scope, additional task*

**RCM of Prioritized Systems**
*(potential of benefit)*


**Recommendations of frequency and scope** *PM, PdM, OH*

**Identification of equipment of Concern**
*High BD, New failure modes, repeat failures, high losses*

**Tracking of Performance & Maint.**
*PM, BD, outages, losses, trips*

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

# Approach for Auxiliary Power Optimisation

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**ENERGY SAVING**

Stopping of equipment when it is not required
Stopping a mill at part load

Operation of mill with low specific energy consumption

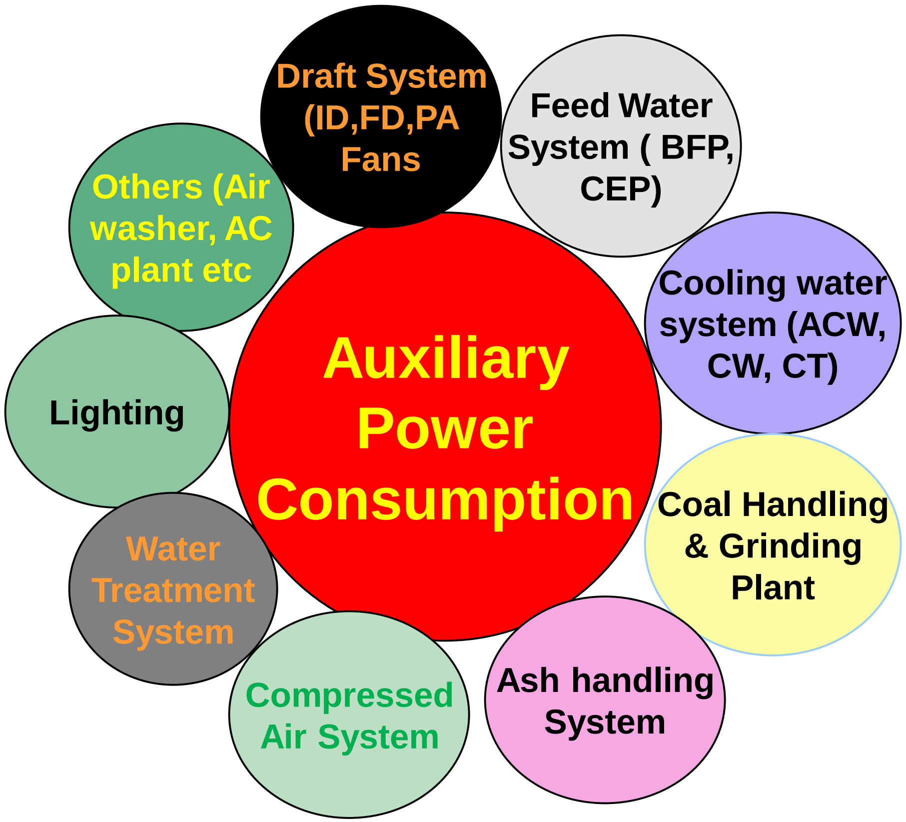
**ENERGY CONSERVATION**

Reduction in
the amount of energy
consumed in
a process or system, or by
an organisation or society,
through

**ENERGY EFFICIENCY**

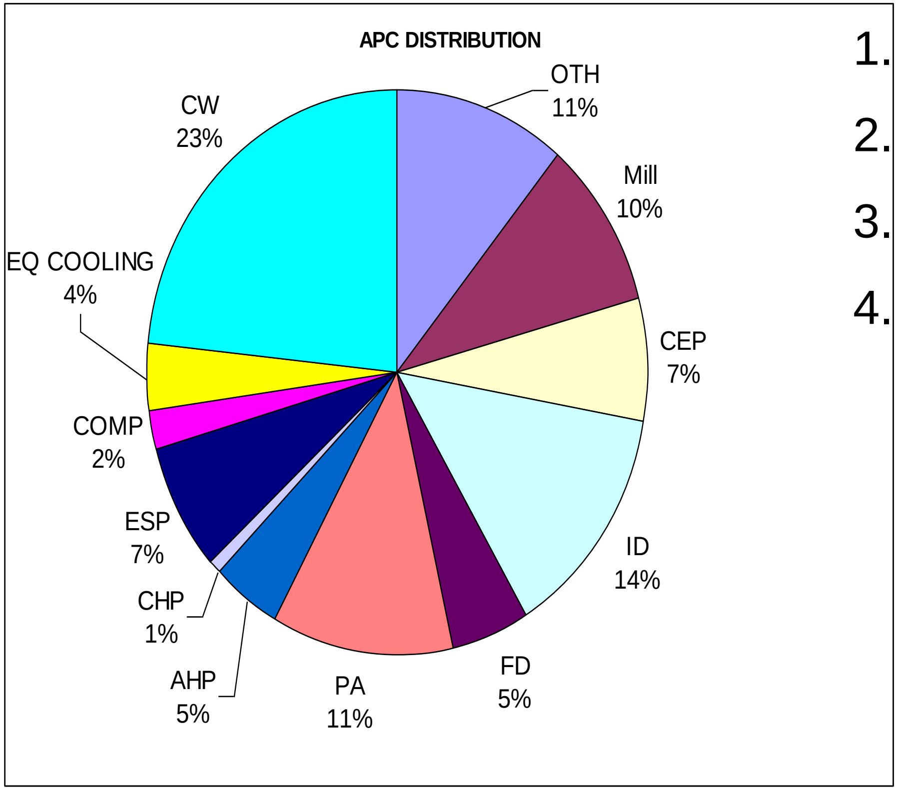
Energy efficiency refers to the same output from a device using less energy

# APC - ELEMENTS



# SYSTEM WISE SHARE OF APC

## 500 MW UNIT- WITHOUT MD BFP




1. Draft Power Consumption - 30%
2. CW System Power Consumption - 23%
3. Milling Power Consumption – 10%
4. CEP Power Consumption – 7%

# EFFECT OF PARAMETER ON DRAFT POWER

| Parameter | Effect on Fan Power | | |
|---|---|---|---|
| | FD Fan | ID Fan | PA Fan |
| High Excess Air | increase | increase | |
| High APH Seal Leakage | increase | increase | increase |
| High APH FG and Air DP due to APH choking | increase | increase | increase |
| High SA duct leakage/deposit | increase | - | - |
| High PA duct leakage/deposit | - | - | increase |
| High FG duct leakage/deposit | - | increase | - |
| High PA header pressure and flow | | | increase |
| Deposits formation in impellers/casings / FG duct | increase | increase | increase |
| Fan body – for holes/cracks | increase | increase | increase |
| Erosion of impeller blades | increase | increase | increase |

# ENERGY AUDIT OF BOILER DRAFT SYSTEM

## ACTION PLAN FOR REDUCTION OF DRAFT POWER

- Attend secondary air duct leakage
- Attend primary air duct leakage
- Arrest air in-leak in the draft system by oxygen measurement at different section of duct (Oxygen Survey).
- Optimisation of oxygen as high excess air for combustion results in increase FD ,ID and PA Fan aux power.
- Optimisation of primary air flow to reduce PA fan aux power
- Remove deposit formation in impellers and casing

# STRATEGIES FOR REDUCTION OF AUXILIARY POWER CONSUMPTION

- Operation of unit during Part load operation ( Saving 300 KW/hr in one unit)
- Reduction of force outages (Unit tripping)
- Optimisation Number of CW pumps during winter season considering condenser
  optimum vacuum and sub-cooling
- Optimisation of mill operation during part load ( Reduction of No of mills )
- Avoid Recirculation BFP AND CEP by rectifying valve passing
- BFP Cartridge Replacement on basis of sp power consumption
- Minimum utilisation of MDBFP where TDBFP available.
- Optimisation of oxygen ( Reduction of aux power of FD fan and ID fan

# Improvement through O&M Practices

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# Improvement through O&M Practices

- **Monitoring of deviation** of critical parameters and information used for performance problem analysis and decision support need to be developed.
- **Timely detection of problems** like condenser vacuum, Mill & APH performance deterioration, high sprays, dry gas loss, high make up and cycle isolation **Focus on major controllable losses**
- **Combustion & soot blowing optimization**
- **Chemical dosing for CW system** to improve CW quality , Condenser and Cooling Tower Performance
- **Stoppage of additional / auxiliary equipment** when not needed and avoidance of idle running
- **Strategic operation** of efficient units at higher loading factor
- Use of **Opportunity cleaning** of condensers & air heaters

# Improvement through O&M Practices

- Proper & Optimum coal blending is a challenge for O&M. Some issues of importance are :
  - High Moisture
    The moisture in the imported coal is of great concern and hence, depending on the type of blending, the hot air temperature is maintained.
  - Safe operation / flame stability
    Like the volatile matter yield, the heating value contained in the volatiles influences flame stability and heat release profile in the boiler
  - Furnace slagging/ clinkering
    Slagging/fouling characteristic of blended coal is an important factor. The characteristics of ash are studied to arrive at the slagging potential and correct blend ration
  - Use of ground hopper, payloader, 30% capacity stack reclaimer

- Continuous awareness program for O&M engineers on all aspects of efficiency and auxiliary power consumption.

# Energy Audits & Structured Interventions for APC reduction

- Energy Audits of the following equipment/system to be in focus
  - Insulation
  - Aux Power Consumption
  - Water system
  - Lighting System
- Monitoring & optimization of Auxiliary during
  - Startups,
  - Shut down of plant
  - idle running
- Auxiliary optimization during low load operation

# O&M Practices – Overhaul Effectiveness

- **Thrust on Overhaul Preparedness Activity**
  - Pre OH activities (Surveys, testing, Unit data collection etc.)
  - Identification of defects and Planning of activity and its inclusion in the engineering declaration
  - Overhaul work scope Finalization based on : Integrated inputs from Work Order analysis, Performance degradation & GAP, Audit, Study findings, OEM recommendation etc.
  - Monitoring cycle of Spares, consumables & contracts, 24 months in advance
- **Optimization of overhaul duration and intervals based on**
  - Learning from previous OH
  - Operational Parameters ,performance parameters and equipment condition between two overhaul, loss recovery pattern, for taking appropriate decision
- Activity Protocols & Check list for Pre & Post Inspections
- Cost benefit and its validation
- Sustenance of performance improvements after Overhauling

# New Initiatives And Technology

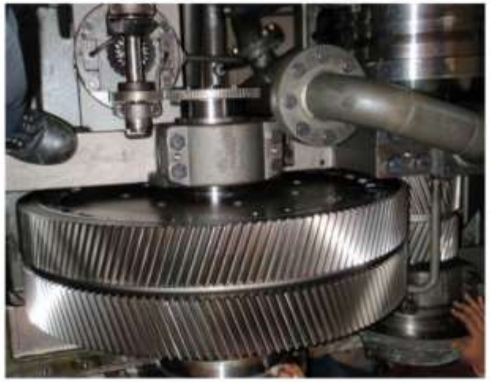
Focus on new Technologies : adoption of energy efficient technologies in existing units

- ❖ New technologies (VFDs, Pump Coating, low energy consumption bearings & conveyors etc.)
- ❖ Energy Efficient Upgrades (Energy Efficient motors, BFP Cartridge)
- ❖ Boiler, Turbine, Pumps, Mills & Air Heater & material upgrades
- ❖ CFD study for duct modification to reduce draft loss
- ❖ Online Energy management System for APC
- ❖ Real-time Tracking of efficiency, online parameters using PI data
- ❖ Start up tracking and online chemical & critical parameter
- ❖ Early warning System like APR

# New Technologies Adopted by Utilities

## Reduction in BFP Hydraulic Coupling Slip Losses

### Reduction in slip loss of BFP 1B hydraulic coupling in U-1



Modified Gear ratio retrofitted in existing hydraulic coupling

Gear Ratio changed from 165/41 to 133/36

| Improvement in APC in KW | Investment in Rs Crs | Net saving in Rs Crs | Saving of coal in MT | $CO_2$ Reduction in MT |
|---|---|---|---|---|
| 584 | 1.05 | 1.61 | 1003 | 1457 |

# NEW TECHNOLOGIES ADOPTED BY UTILITIES

## Reduction of Specific Raw water consumption

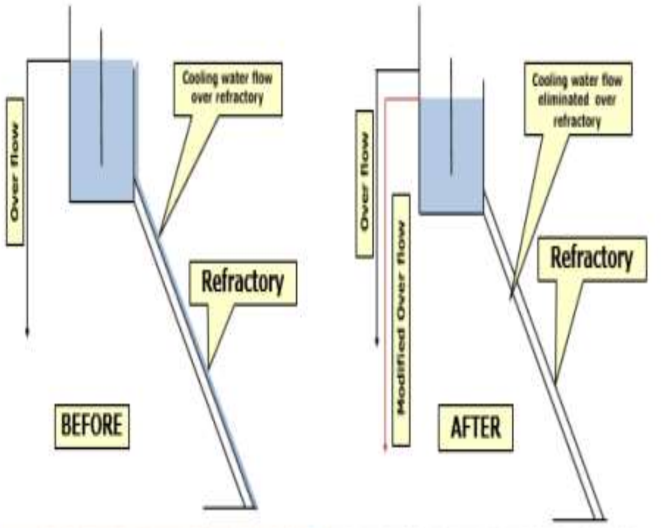
**Why innovative**: LC cement is adopted for Boiler. In initial design, Water is continuously overflowed from seal through to refractory.

**Savings achieved:** Reduction of monthly allocation quantity from 24 Cusec to 20 Cusec

**Financial saving achieved:** 2.91 Crore

**Investment** : 9.2 Lacs

**Replicability : Yes**




| Water flow 210 Tons/hr. | Water flow 40 T/hr. |
| --- | --- |

### IDENTIFICATION OF OPPORTUNITY

- Specific raw water consumption reduction is a strategic objective of GKEL for sustenance concern. Raw water cost also has significant impact on O&M cost . Reduction of SRWC will aid Zero discharge , Raw water cost and auxiliary power consumption. With analysis it is observed that CT blow down is the most controllable contributor for Raw water consumption and Root cause for the Raw water consumption is Boiler hopper refractory cooling and it also disturbs the Water balance of AHP. This resulted in difficulty in maintaining zero discharge.

### POSSIBLE SOLUTION

- Refractory metallurgy was changed to improved quality refractory
- refractory application Seal trough overflow line modified to eliminate cooling water
- SOP finalized and training provided to field operator

### IMPLEMENTATION

- Complete replacement of refractory

# Issues & Challenges

- Top management support for efficiency improvements
- Awareness of efficiency impacts
- Skills, Knowledge, Advanced tools, Specialized equipment's
- Limited investment for efficiency restoration: repair / replacement
- System and planning for efficiency monitoring and restoration
- Changing established utility practices takes time

# Conclusion

- PAT: Win-Win situation for all stake holders
- Energy efficiency can be achieved by adopting better O&M practices
- Operational excellence not enough to bring high degree of improvements
- Maximize Usages of opportunity for recovery of efficiency loss
- Focus on overhaul effectiveness & sustenance of improvements
- Need to integrate new systems, technology & practices
- Efficiency & Reliability Improvement through R&M for old units
- Heat rate improvement is a journey without goal post, a continuous process.
- Partial loading due to coal shortage, scheduling is a challenge for maintaining higher efficiency and auxiliary power consumption

# Thank you

# 200MW Unit Typical Per Year Cost Implication of 10 kcal/kWh HR Deviation

| Impact of HR Deviation | Coal Saving Per Year | Cost Saving Per Year |
|---|---|---|
| 10 kcal/kWh | 3080 Tons | Rs. 1.30 Cr |

***'What can not be measured can not be saved'***

***Assumption : GCV 3700 kcal/kg , Coal Cost Rs 4250 per Ton, PLF 65%,***

# HR Deviation Real Time Program

- HR deviation programs are available on DAS
- Ideal location for Real time program.
- Software should be user friendly and it should be possible to change the targets.
- Reliability of station instruments shall have to be maintained through rigorous efforts.
- Off line PC based system can work in old units with a data link to DAS.

# NEW TECHNOLOGIES ADOPTED BY UTILITIES

| Name of the Project | Brief description on why innovative | Trigger for implementing the project | Replicability | Impact on SEC |
|---|---|---|---|---|
| Cooling water pump motor pole change | "CWP speed reduction by CW motor pole changing from existing 16 to 20 Pole.<br>02 Nos. of CW motors (11kV,5.25MW, 373RPM,16 pole) are installed for individual unit & 06 nos. for 03 Units. At present, in normal operating condition, CW motors power consumption is 9.5 MW with both pumps running at full speed i.e., 370 RPM. However, during single pump operation, CW motor power consumption is in the range of the 4.2 - 4.7 MW.As we are operating our units mostly at less load, There is a high potential of power savings due to less Cooling water flow required.<br>Study from M/s VVR Consultant has highlighted that total flow of CW pumps are more than total design flow requirement. Further, to meet the design / process efficiency M/s VVR Consultant has suggested to reduce the one of the existing motor speeds from 370 RPM to 328 RPM." | At Less Load, Low Delta T across condenser due to high CW flow | Implemented in U2,U3 | 1000 KW in 1 unit |