Council of Enviro Excellence

5th NATIONAL POWER-GEN ENERGY EFFICIENCY AWARDS-2026

5TH NATIONAL POWER-GEN ENERGY EFFICIENCY

SUMMIT AND AWARDS 2025

Enhancing Efficiency in Indian Thermal Power Plants

ENERGY EFFICIENT TECHNOLOGIES FOR THERMAL POWER PLANTS- A DECARBONIZATION JOURNEY FOR FOSSIL FUELS BASED ELECTRICITY

MR. AMITABH SRIVASTAVA

5th National Power-Gen Energy Efficiency Summit
Optimizing Heat Rate: Enhancing Efficiency in Indian Thermal Power Plants

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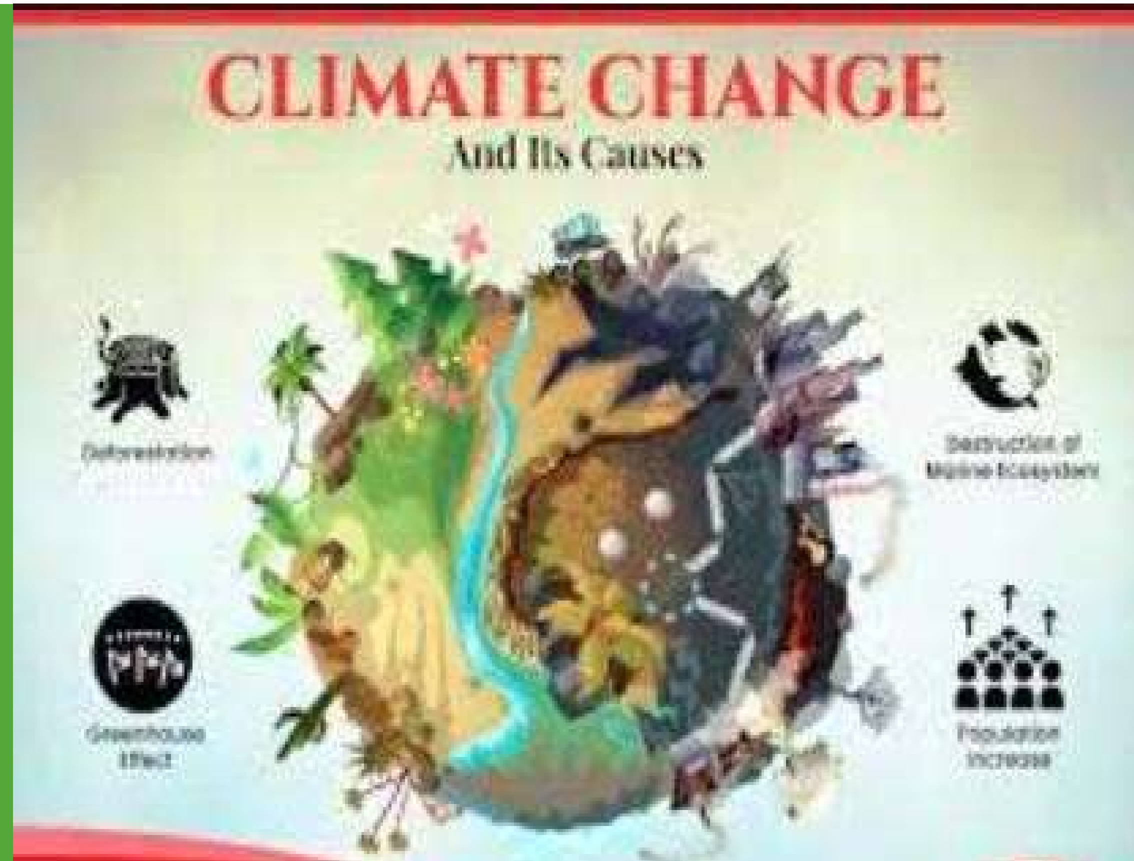
Climate change : Change in the average surface temperature on Earth. The average temp. on our planet has been 15°C, but the past few years have seen drastic variations in the same, both up and down

REASON : Overexploitation of fossil fuels by humans and deforestation

RESULT: Release of carbon dioxide & other greenhouse gases, such as methane and nitrous oxide, into the atmosphere

1. Rise in the sea level
2. Extreme weather conditions
3. Melting polar ice
4. Floods
5. Droughts causing wildfires



What is Heat Rate?

The heat rate is defined as the total amount of energy required to produce one kilowatt-hour (kWh) of electricity by an electric generator or power plant

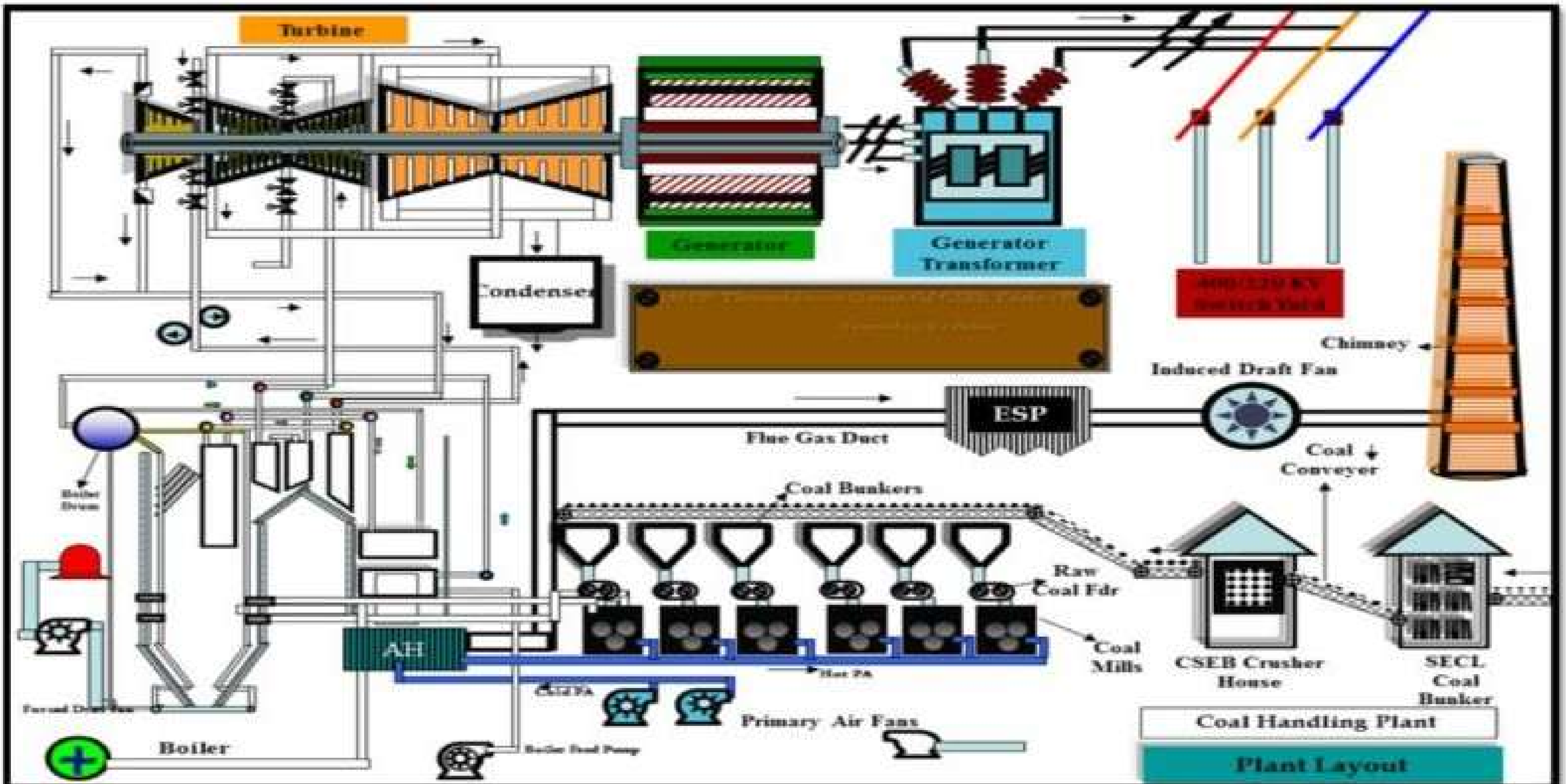
$$\text{Heat Rate} = \frac{\text{Thermal Energy Input}}{\text{Electric Energy Output}}$$

Relation between efficiency and heat rate

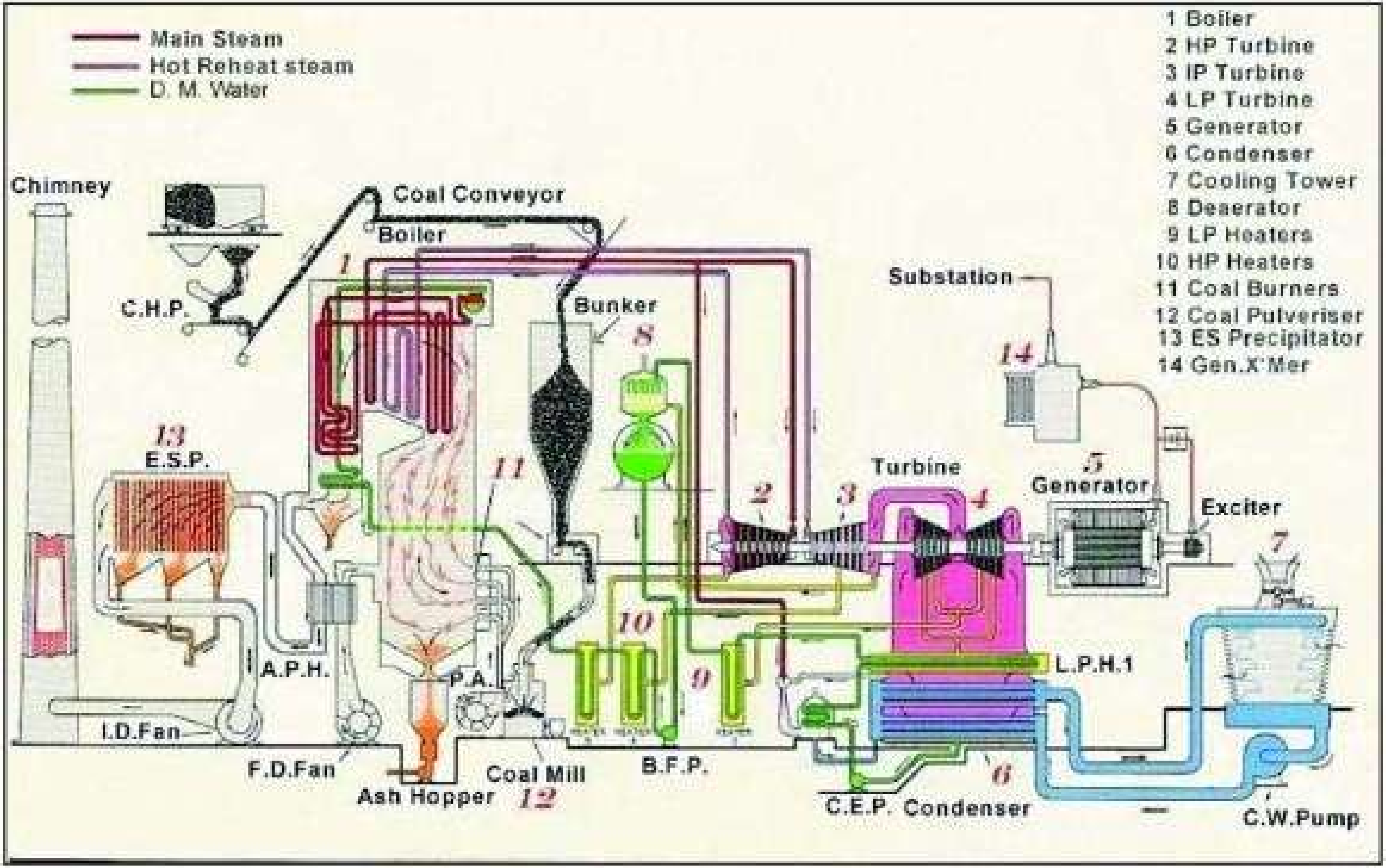
$$\textbf{Efficiency} \propto \textbf{1/ Heat Rate}$$

If a power plant converted 100% of the chemical energy in the fuel into electricity, the plant would have a heat rate of 860 kcal/kWh.

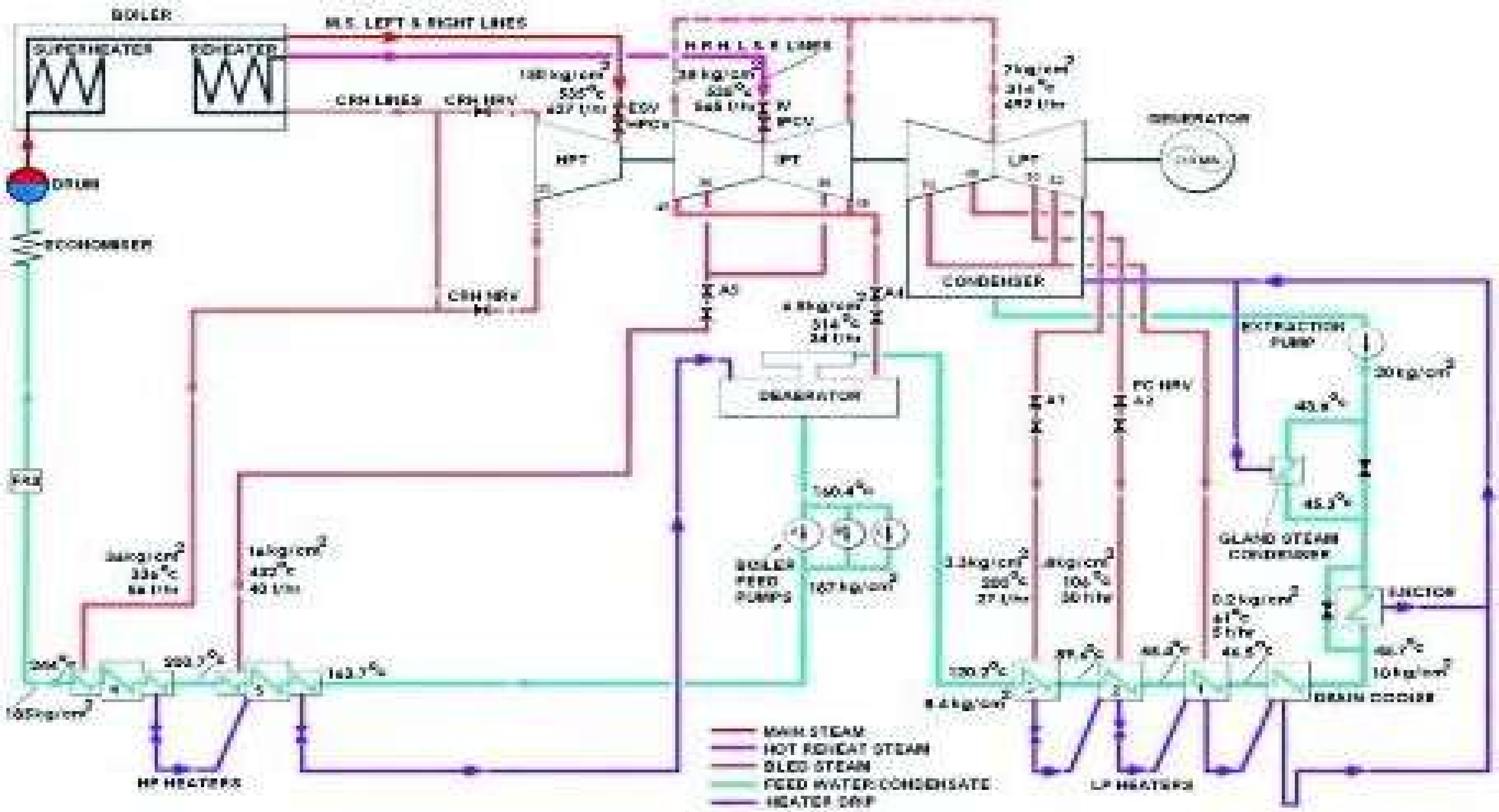
Coal Based Thermal Power Plant Schematic Diagram



Important Components of Typical Coal Based Thermal Power Plant



Heat & Mass Balance Diagram
Turbine Cycle Heat Rate

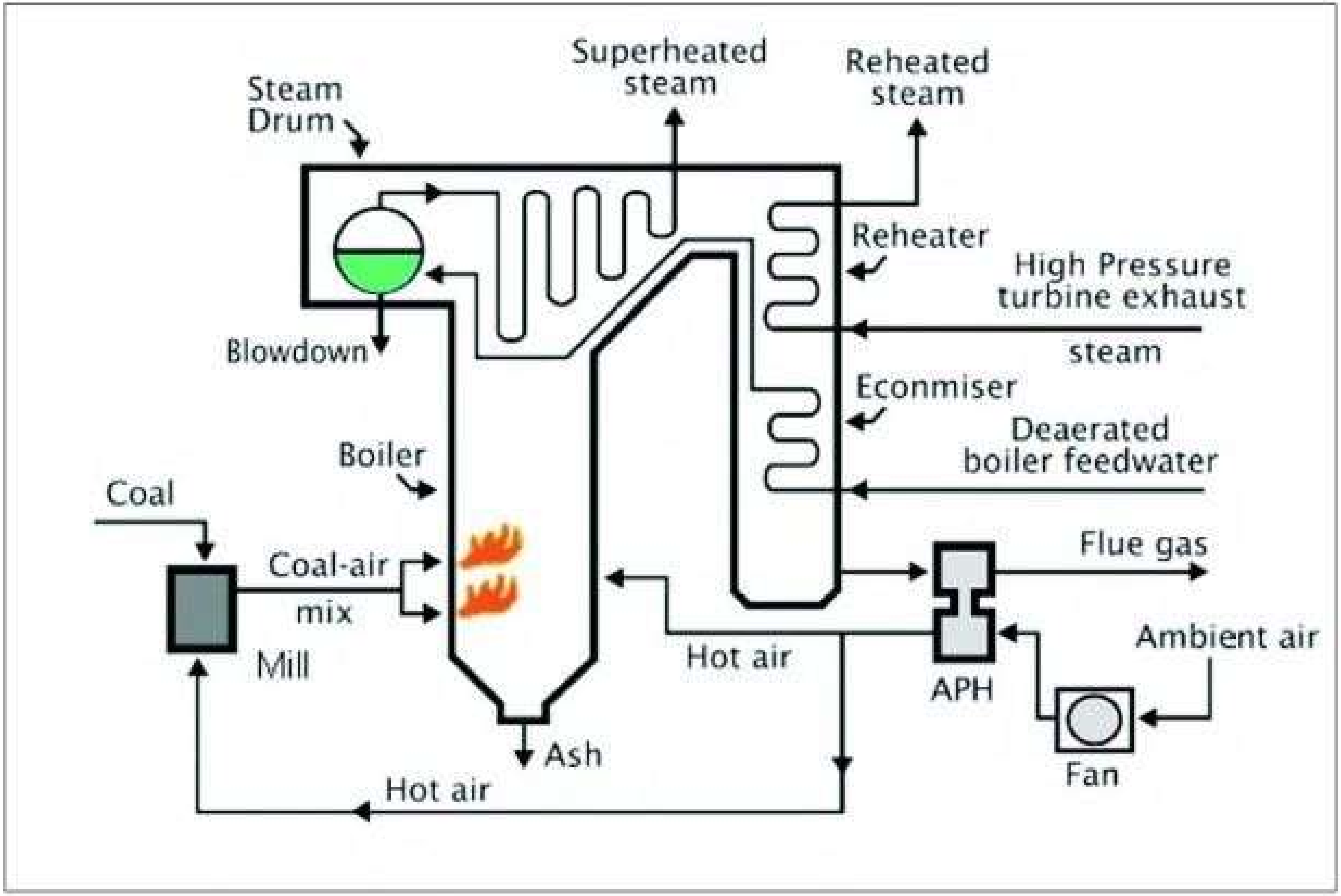


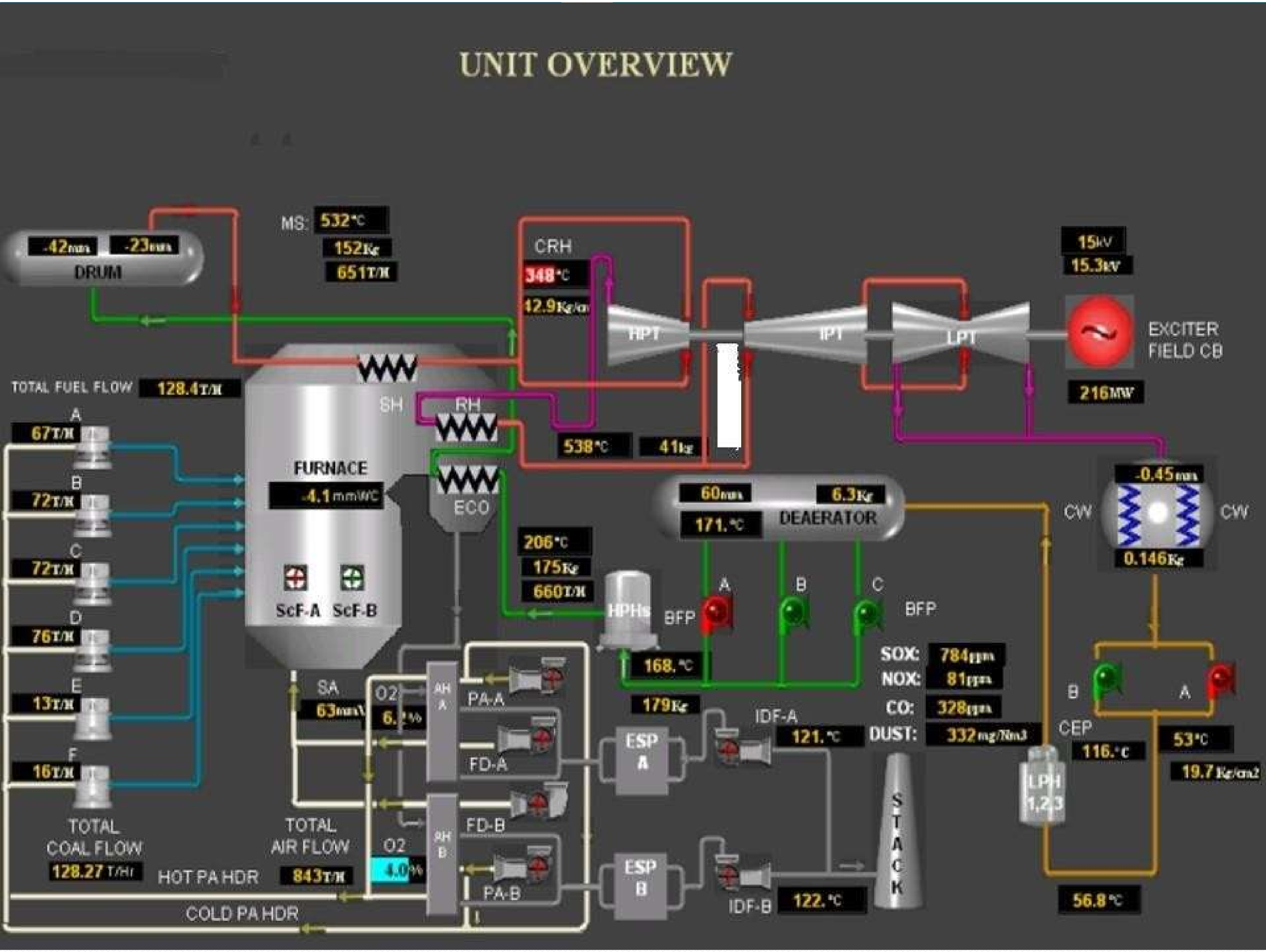
Typical Auxiliary Power consumption in Thermal Power Plant

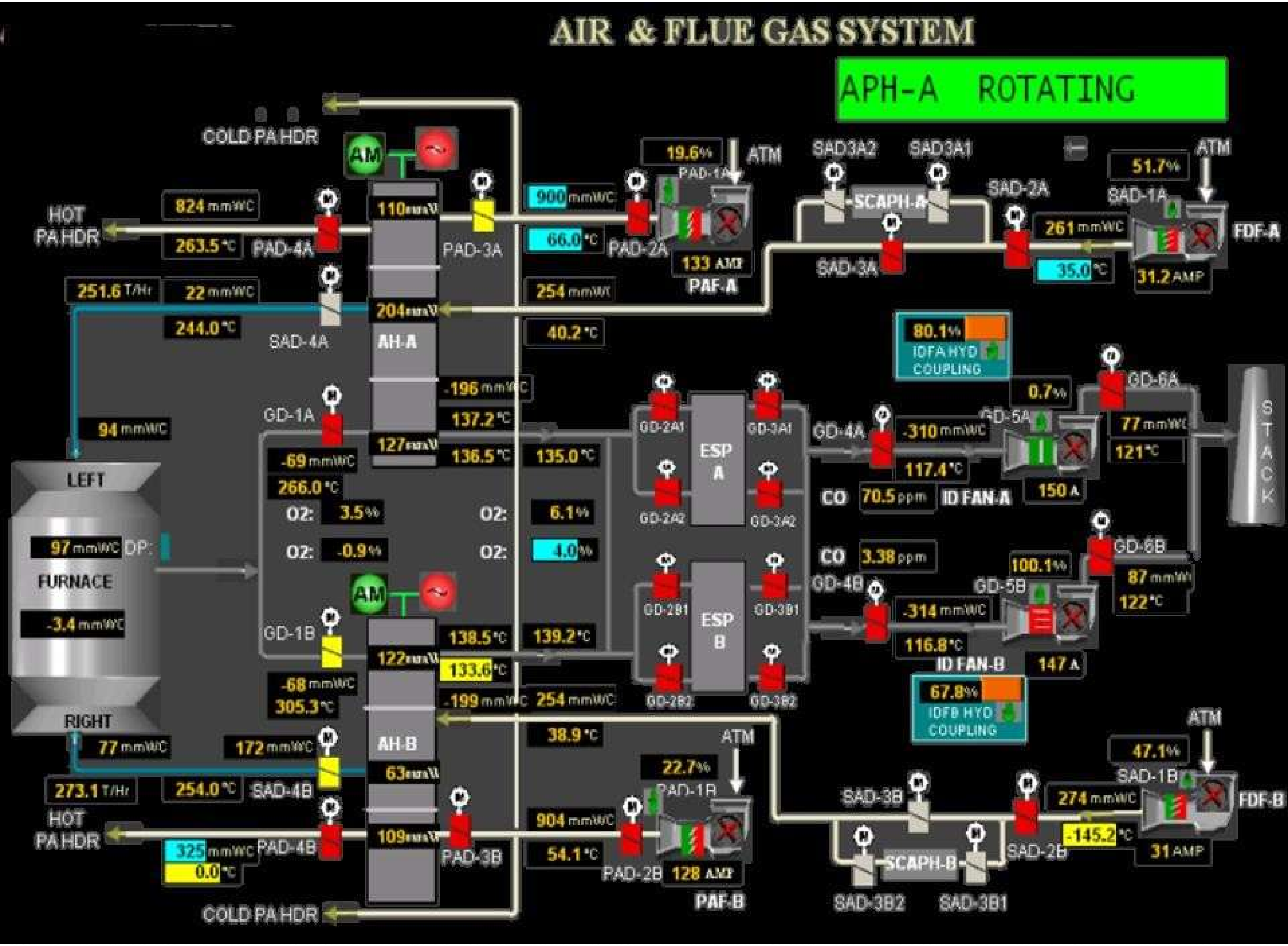
Equipment Ref.	500 MW		210 MW		110 MW	
	% Gen	% APC	% Gen	% APC	% Gen	% APC
BFP	0.00*	0.00*	2.70	33.60	2.94	24.50
CEP	0.40	5.70	0.27	3.34	0.36	3.00
CWP	1.00	14.20	0.66	8.31	1.26	10.50
IDF	1.30	18.70	1.26	15.80	1.71	14.23
PAF	0.60	8.50	0.68	6.50	1.78	14.46
FDF	0.30	4.10	0.40	5.00	0.26	2.13
Mills	0.60	8.20	0.58	7.23	0.83	6.92
CT fans	0.23	3.20	0.32	3.54	0.48	4.00
Air Comp.	0.08	1.20	0.12	1.56	0.24	2.00
A/C Plant	0.04	0.50	0.08	0.94	0.11	0.92
CHP	0.12	1.70	0.14	1.70	0.29	2.41
AHP	0.09	1.20	0.13	1.66	0.31	2.54
Lighting	0.06	0.80	0.08	1.00	0.08	0.68
others	2.23	31.90	0.60	7.44	1.36	11.32
APC	**7.00**	**100.00**	**8.00**	**100.00**	**12.00**	**100.00**

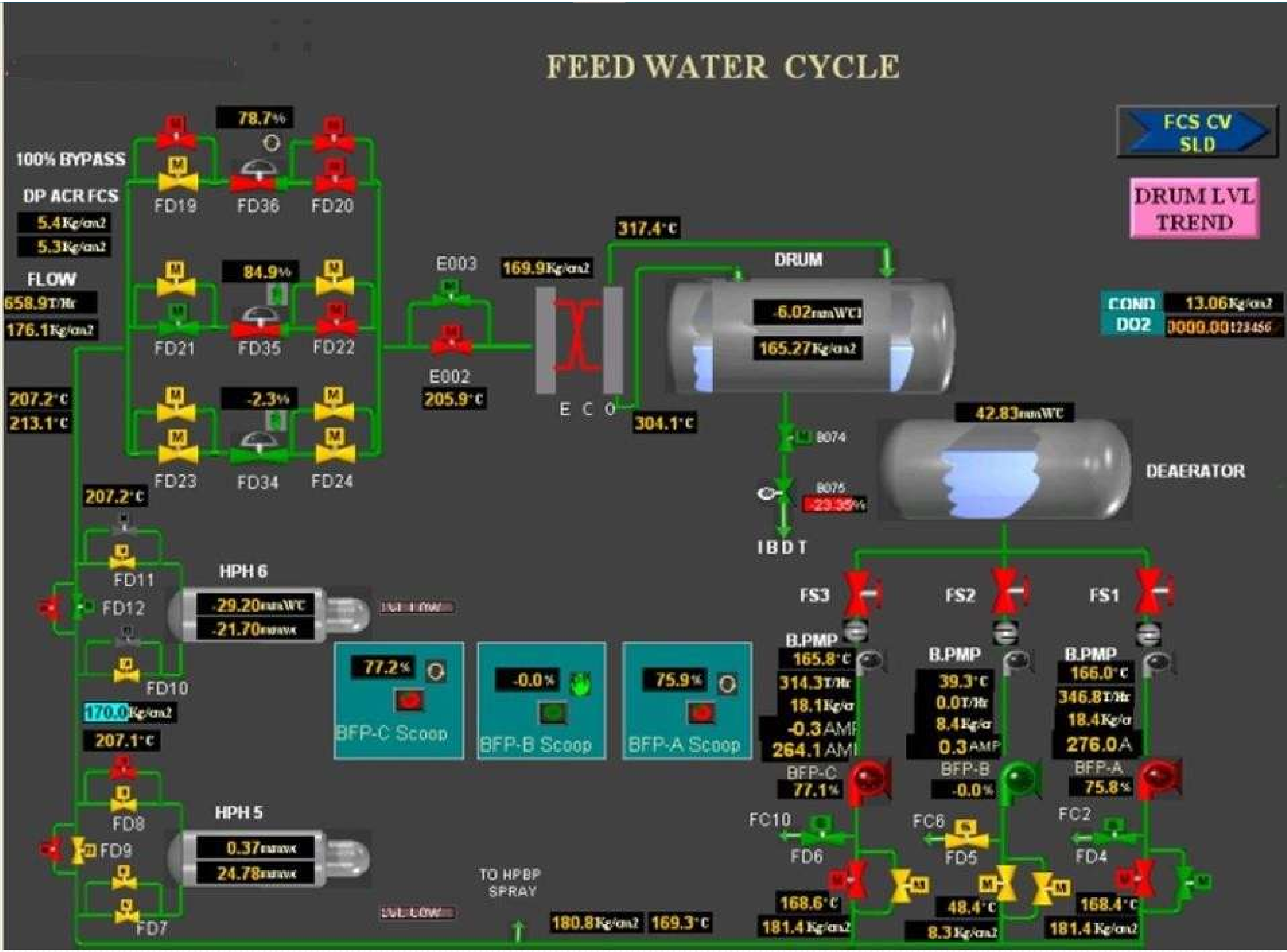
BFP – Boiler feed pump, CEP – Condensate extraction pump, CWP - Cooling water pump, IDF – Induced draft fan, PAF – Primary air fan, FDF – Forced draft fan, CT fans – Cooling tower fans, CHP – Coal handling plant, AHP – Ash handling plant, APC – Auxiliary power consumption and % Gen - % Generation.

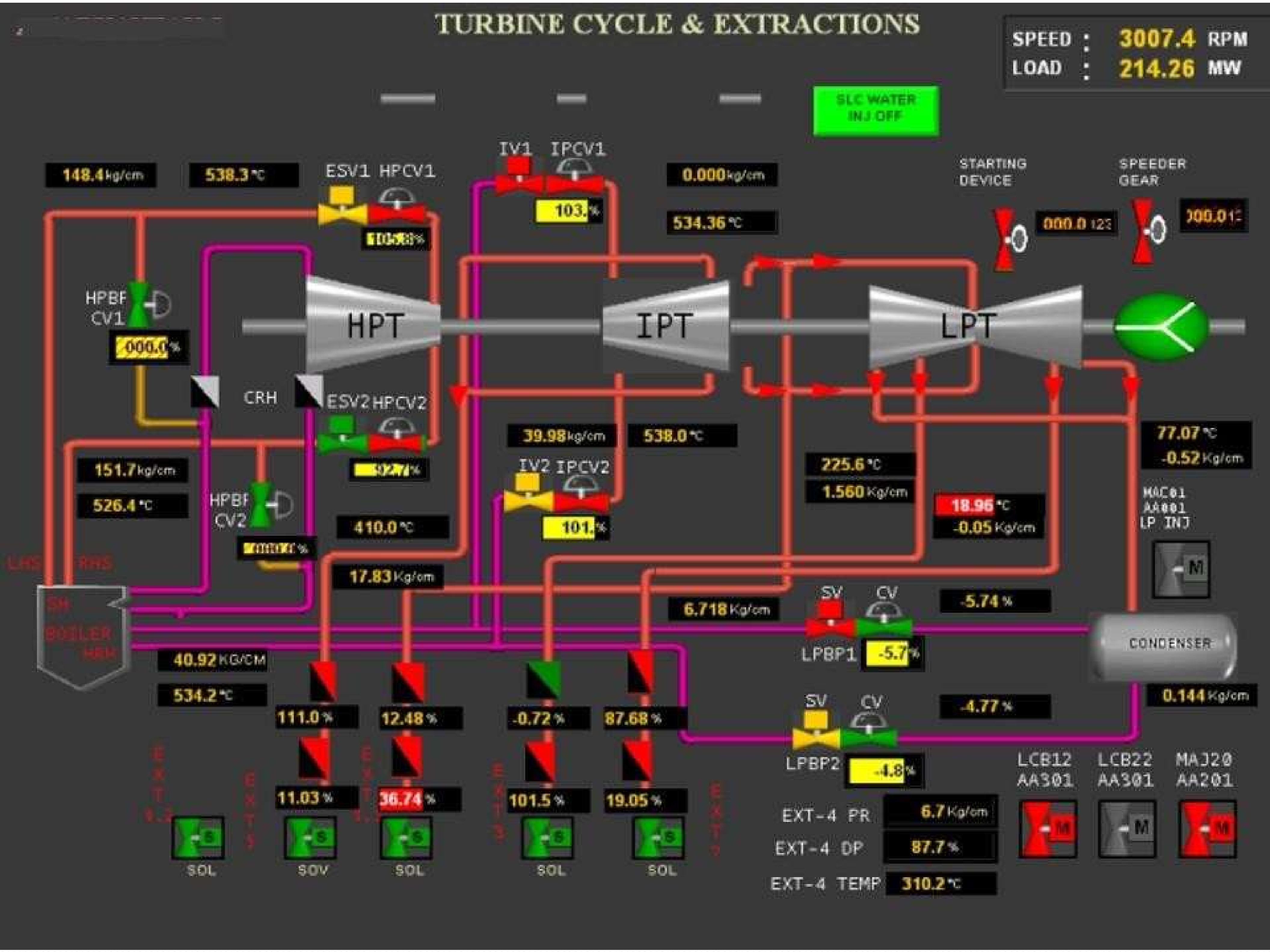
Coal Fired Power Plant Boiler




UNIT OVERVIEW
DRUM
-42mm
-23mm
MS:
532°C
152Kg
651T/H
CRH
348°C
42.9Kg/cm
HPT
IPT
LPT
15kV
15.3kV
EXCITER
FIELD CB
216MW
TOTAL FUEL FLOW
128.4T/H
SH
RH
538°C
41kg
FURNACE
-4.1 mmWC
ECO
ScF-A
ScF-B
A
67T/H
B
72T/H
C
72T/H
D
76T/H
E
13T/H
F
16T/H
DEAERATOR
60mm
6.3Kg
171.°C
-0.45mm
CW
CW
0.146Kg
206°C
175Kg
660T/H
HPHs
BFP
BFP
168.°C
179Kg
SOX:
784ppm
NOX:
81ppm
CO:
328ppm
DUST:
332mg/Nm3
SA
63mm
O2
AH A
PA-A
FD-A
IDF-A
121.°C
ESP A
ESP B
FD-B
AH B
O2
4.0%
PA-B
IDF-B
122.°C
STACK
CEP
116.°C
53°C
19.7Kg/cm2
LPH 1,2,3
56.8°C
TOTAL COAL FLOW
128.27 T/Hr
TOTAL AIR FLOW
843T/H
HOT PA HDR
COLD PA HDR


AIR & FLUE GAS SYSTEM
APH-A ROTATING
COLD PA HDR
HOT PA HDR
824 mmWC
263.5 °C
PAD-4A
110 mmWC
PAD-3A
900 mmWC
66.0 °C
19.6%
PAD-1A
ATM
PAD-2A
133 AMP
PAF-A
SAD3A2
SAD3A1
SCAPH-A
SAD-3A
SAD-2A
261 mmWC
35.0 °C
51.7%
SAD-1A
ATM
FDF-A
31.2 AMP
251.6 T/Hr
22 mmWC
244.0 °C
SAD-4A
204 mmWC
AH-A
254 mmWC
40.2 °C
80.1%
IDFA HYD COUPLING
-196 mmWC
137.2 °C
GD-1A
94 mmWC
127 mmWC
136.5 °C
135.0 °C
-69 mmWC
266.0 °C
GD-2A1
GD-3A1
ESP A
GD-2A2
GD-3A2
GD-4A
-310 mmWC
117.4 °C
CO 70.5 ppm
ID FAN-A
GD-5A
0.7%
GD-6A
77 mmWC
121 °C
150 A
STACK
LEFT
O2: 3.5%
O2: 6.1%
O2: -0.9%
O2: 4.0%
97 mmWC DP:
FURNACE
-3.4 mmWC
RIGHT
CO 3.38 ppm
GD-4B
GD-2B1
GD-3B1
ESP B
GD-2B2
GD-3B2
100.1%
GD-5B
GD-6B
87 mmWC
122 °C
-314 mmWC
116.8 °C
ID FAN-B
147 A
67.8%
IDFB HYD COUPLING
GD-1B
122 mmWC
138.5 °C
139.2 °C
133.6 °C
-68 mmWC
305.3 °C
-199 mmWC
254 mmWC
38.9 °C
AH-B
77 mmWC
172 mmWC
SAD-4B
63 mmWC
273.1 T/Hr
254.0 °C
ATM
22.7%
PAD-1B
109 mmWC
PAD-4B
325 mmWC
0.0 °C
PAD-3B
904 mmWC
54.1 °C
PAD-2B
128 AMP
PAF-B
SAD-3B
SCAPH-B
SAD-3B2
SAD-3B1
SAD-2B
274 mmWC
-145.2 °C
47.1%
SAD-1B
ATM
FDF-B
31 AMP


FEED WATER CYCLE
FCS CV SLD
DRUM LVL TREND
100% BYPASS
DP ACR FCS
5.4Kg/cm2
5.3Kg/cm2
FLOW
658.9T/Hr
176.1Kg/cm2
78.7%
84.9%
-2.3%
FD19
FD36
FD20
FD21
FD35
FD22
FD23
FD34
FD24
207.2°C
213.1°C
207.2°C
E003
E002
205.9°C
169.9Kg/cm2
317.4°C
DRUM
-6.02mmWC
165.27Kg/cm2
E C O
304.1°C
COND
13.06Kg/cm2
DO2
42.83mmWC
DEAERATOR
8074
8075
IBDT
HPH 6
FD11
FD12
-29.20mmWC
-21.70mmwc
FD10
170.0Kg/cm2
207.1°C
77.2%
BFP-C Scoop
-0.0%
BFP-B Scoop
75.9%
BFP-A Scoop
FS3
FS2
FS1
B.PMP
165.8°C
314.3T/Hr
18.1Kg/c
-0.3AMP
264.1AMP
B.PMP
39.3°C
0.0T/Hr
8.4Kg/c
0.3AMP
B.PMP
166.0°C
346.8T/Hr
18.4Kg/c
276.0A
BFP-C
77.1%
BFP-B
-0.0%
BFP-A
75.8%
HPH 5
FD8
FD9
0.37mmwc
24.78mmwc
FD7
TO HPBP SPRAY
180.8Kg/cm2
169.3°C
FC10
FD6
FC6
FD5
FC2
FD4
168.6°C
181.4Kg/cm2
48.4°C
8.3Kg/cm2
168.4°C
181.4Kg/cm2



TURBINE CYCLE & EXTRACTIONS
SPEED : 3007.4 RPM
LOAD : 214.26 MW
SLC WATER INJ OFF
148.4 kg/cm
538.3 °C
ESV1 HPCV1
IV1 IPCV1
103.%
0.000 kg/cm
534.36 °C
STARTING DEVICE
000.0
SPEEDER GEAR
HPBF CV1
.000.0%
HPT
IPT
LPT
CRH
ESV2 HPCV2
92.7%
39.98 kg/cm
538.0 °C
151.7 kg/cm
526.4 °C
HPBF CV2
IV2 IPCV2
101.%
410.0 °C
225.6 °C
1.560 Kg/cm
18.96 °C
-0.05 Kg/cm
77.07 °C
-0.52 Kg/cm
MAC01 AA001 LP INJ
LHS
RHS
17.83 Kg/cm
6.718 Kg/cm
SV CV
-5.74 %
LPBP1
-5.7%
CONDENSER
40.92 KG/CM
534.2 °C
111.0 %
12.48 %
-0.72 %
87.68 %
0.144 Kg/cm
SV CV
-4.77 %
LPBP2
-4.8%
11.03 %
36.74 %
101.5 %
19.05 %
LCB12 AA301
LCB22 AA301
MAJ20 AA201
EXT-4 PR 6.7 Kg/cm
EXT-4 DP 87.7 %
EXT-4 TEMP 310.2 °C
SOL
SOV
SOL
SOL
SOL

ENERGY EFFICIENCY
Energy Audit : Methodology

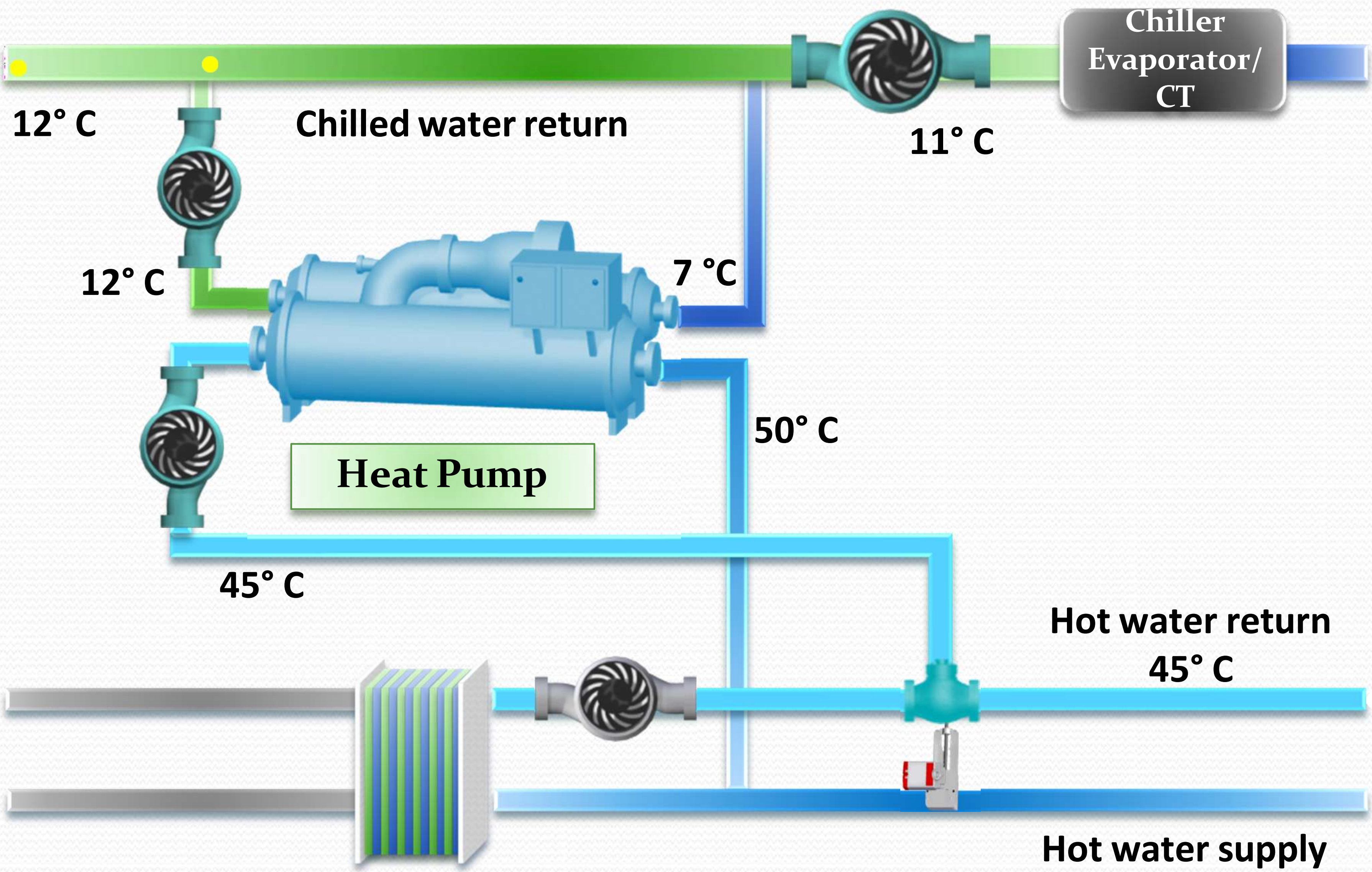
- Audit Step 1 : Data Collection
- Audit Step 2 : Observation, measurement & trials
- Audit Step 3 : Data Analysis & Findings
- Audit Step 4 : Implementing some of the measures and evaluation by trials (Online at equipment)
- Audit Step 5 : Recommendations & Techno-economic evaluation
- Audit Step 6 : Presentation to Top management & Detailed report preparation
- Audit Step 7 : Implementation Action plan preparation & Periodic Review

Electrical	Thermal
Collecting the information on inventory of the electrical equipment installed and its operating parameters (like hours, actual load in kW etc.)	Collecting the information on inventory of the thermal installed and its operating parameters (like hours, Capacity, etc.)
<u>Equipment / Sections</u> • Electrical Systems-Transformer • Electric Motor & Drives • Pump , Fan & Blower • Chiller compressor • Compressed Air System (Generation, Distribution & Utilization) • Lighting System • Harmonic analysis	<u>Equipment / Sections</u> • Boilers & Steam System • Steam Turbine • Deareator • Condenser • LP Heaters • HP Heaters • Refrigeration & Air-conditioning • Cooling Tower •
Review of Loading parameters / reasons for deviations analyzed.	Energy & Mass balances carried out and user end requirements matched with installed capacities.

ENERGY EFFICIENCY
Online Measuring Instruments

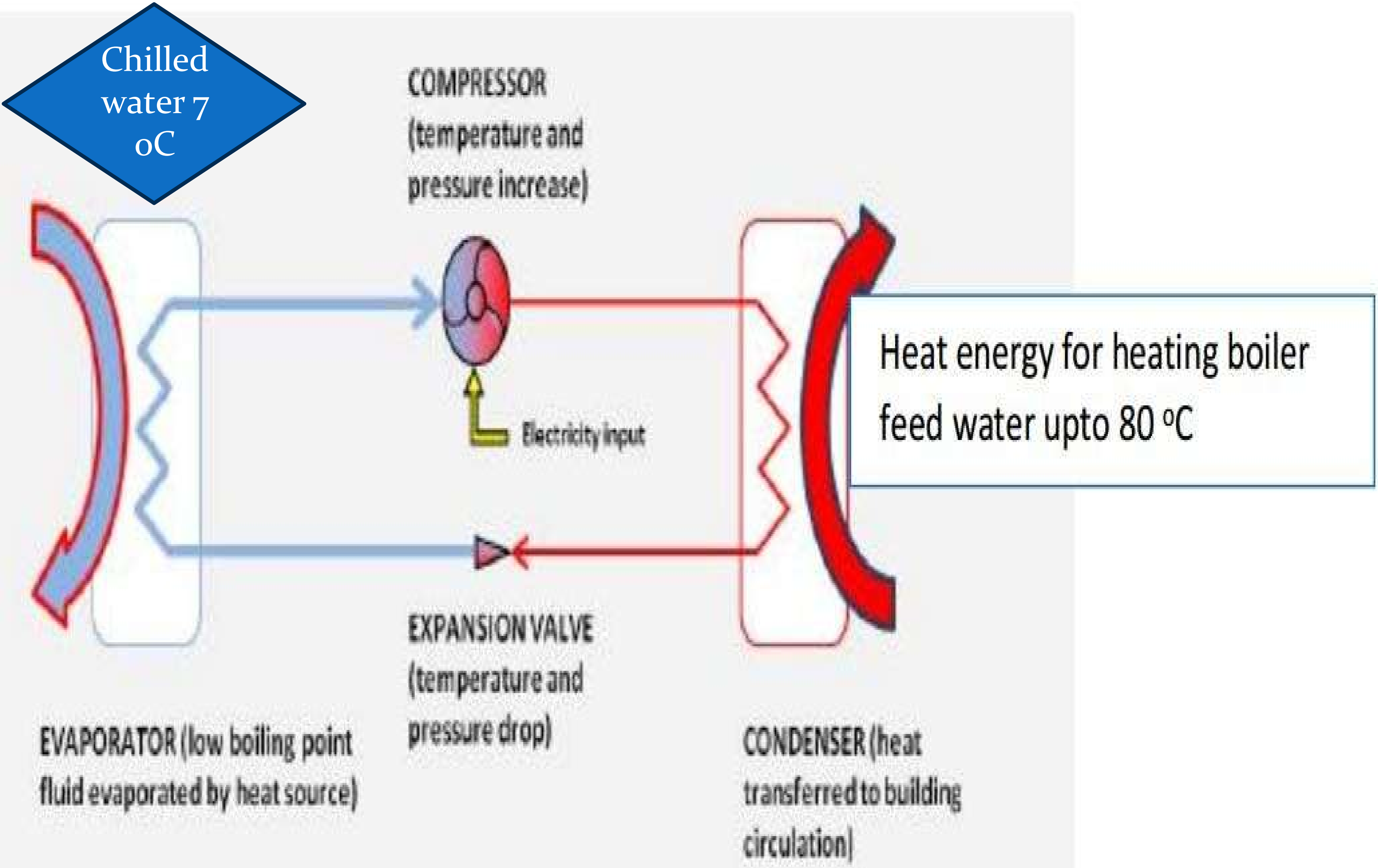
- Load Manager and Harmonic Analyzer
- Anemometer
- Ultrasonic Flow meter
- Digital Thermometer
- Infrared Thermometer
- Flue Gas Analyzer
- Pressure gauge
- Digital manometer
- Ultrasonic leak detector
- Lux Meter, etc.

Heat Pump Working

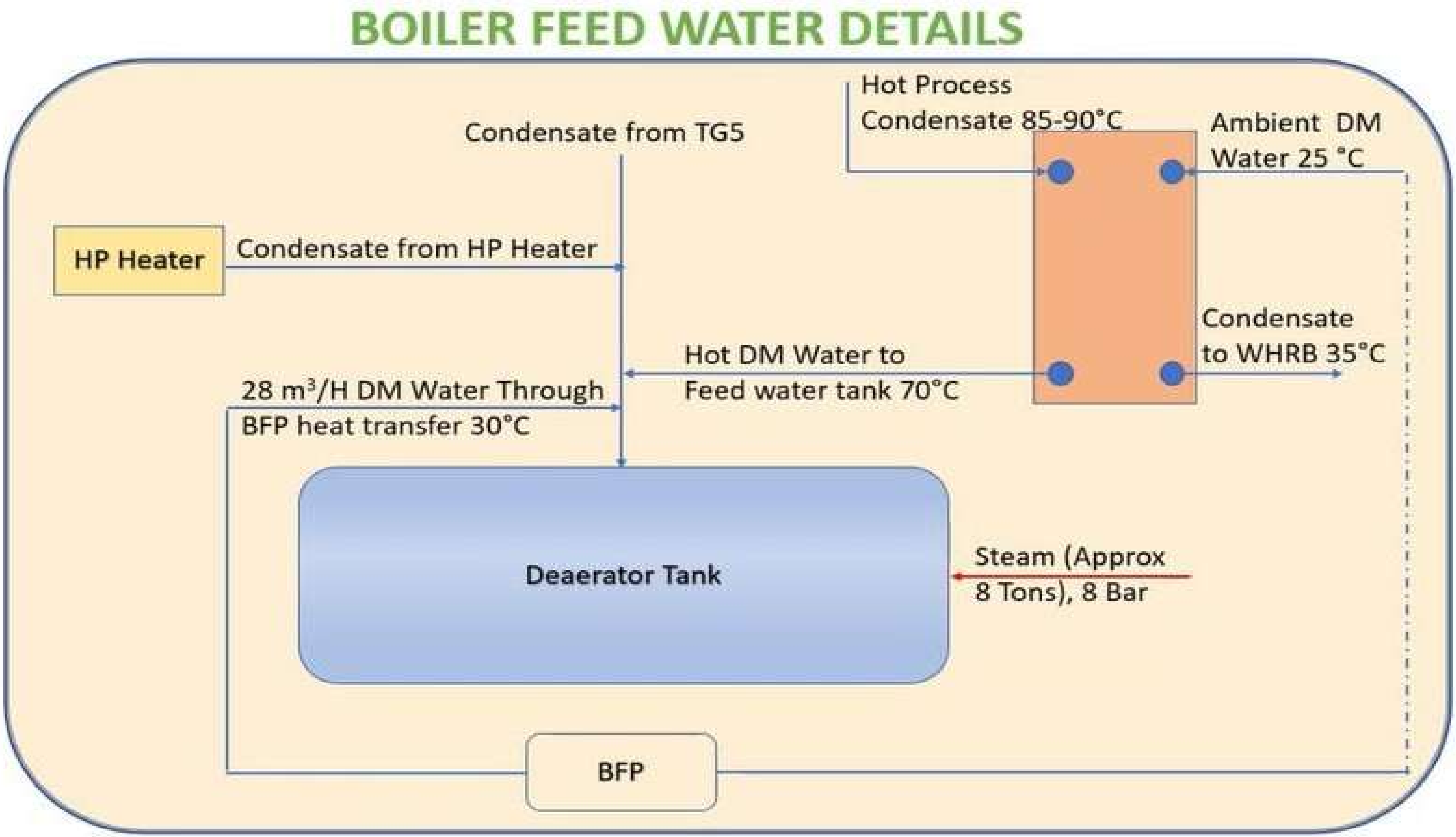


Proven system

WATER SOURCE HEAT PUMP



Case Study – 1 Installation of Water source Heat Pump for Boiler Feed water Preheating



Case Study – 1 Installation of Water source Heat Pump for Boiler Feed water Preheating

Boiler No.	Make	Capacity (TPH)	Operating Pr. (kg/cm2)	Fuel Used
1	CVL	90	87	Coal
2	CVL	90	87	Coal
3	CVL	34	32	Coal
4	CVL	25	32	Coal

Table 1 List of Boilers

Existing Scenario

Two 90 TPH Boiler is running;

28 TPH of makeup water is supplied at ambient temperature to the deaerator, where it is heated to 105°C using steam extracted by Steam Turbine.

Inlet Make up Water temperature = 25°C to 30 °C

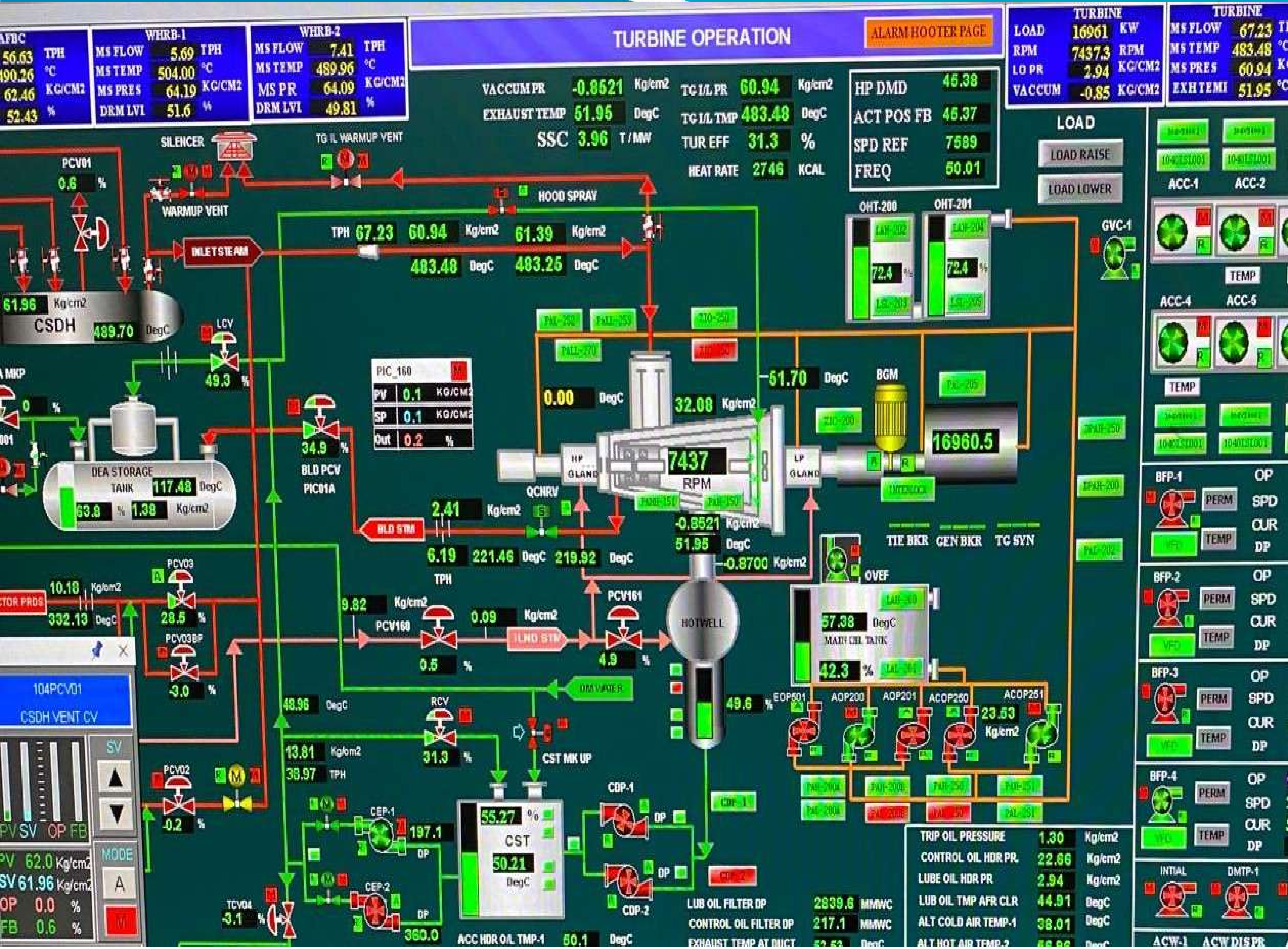
Outlet Make up Water temperature = 80°C

Parameter	UOM	Value
Feed Water Temperature	oC	25
GCV of Fuel (Indian Coal)	kCal/kg	3600
Make up Feed Water flow-rate	TPH	28
Operating days per year	days	324
Annual Steam consumption	Tons/year	20160
Steam generation rate	Rs/kg	2.2
Annual Energy spend for Boiler Make-up water preheating	Rs. Lakh	443.5
Heat pump Electricity consumption	kWh/year	5503741
Heat pump Electricity consumption Cost	Rs Lakh/year	220.15
Annual Chilling TRH production	TRH/year	195668
Electricity consumption for Chilling TRH producing	kWh/year	156534
Net Electricity Consumption by Heat pump	kWh/year	5347207
Electricity Rate Rs/ kWh	Rs/kWh	4
Net Electricity consumption cost by New Heat pump per year after Chilling as byproduct	Rs Lakh/year	213.9
Steam is passed through turbine , more kWh generation	kWh/year	570000

Case Study – 1 Installation of Water source Heat Pump for Boiler Feed water Preheating

Parameter	UOM	Value
Annual Monetary benefit with Electrical power generation	Rs Lakh/year	22.8
Net Monetary Benefit per year	Rs Lakh/year	252.4
Investment for Heat pump installation & Integration with Chilled water system	Rs Lakh	400
Payback period	Years	1.58

- **Heating Output by Heat pump Coal Saved**
- **Chilling Output by Heat pump -Load on existing Chiller is reduced**
- **Steam reduction in Inefficient process of Deaerator**
- **Turbine more Electricity generation by saved steam**
- **GHG emission reduction 2250 Ton/year**


TURBINE OPERATION
ALARM HOOTER PAGE
WHRB-1
MS FLOW 5.69 TPH
MS TEMP 504.00 °C
MS PRES 64.19 KG/CM2
DRM LVL 51.6 %
WHRB-2
MS FLOW 7.41 TPH
MS TEMP 489.96 °C
MS PR 64.09 KG/CM2
DRM LVL 49.81 %
TURBINE
LOAD 16961 KW
RPM 7437.3 RPM
LO PR 2.94 KG/CM2
VACCUM -0.85 KG/CM2
TURBINE
MS FLOW 67.23
MS TEMP 483.48
MS PRES 60.94
EXH TEMP 51.95
VACCUM PR -0.8521 Kg/cm2
EXHAUST TEMP 51.95 DegC
SSC 3.96 T/MW
TG I/L PR 60.94 Kg/cm2
TG I/L TMP 483.48 DegC
TUR EFF 31.3 %
HEAT RATE 2746 KCAL
HP DMD 45.38
ACT POS FB 45.37
SPD REF 7589
FREQ 50.01
LOAD
LOAD RAISE
LOAD LOWER
ACC-1
ACC-2
ACC-4
ACC-5
TEMP
GVC-1
OHT-200
OHT-201
SILENCER
TG IL WARMUP VENT
PCV01
WARMUP VENT
HOOD SPRAY
INLETSTEAM
TPH 67.23 60.94 Kg/cm2 61.39 Kg/cm2
483.48 DegC 483.25 DegC
CSDH
61.96 Kg/cm2
489.70 DegC
LCV
49.3 %
DEA STORAGE TANK
117.48 DegC
63.8 % 1.38 Kg/cm2
PIC_160
PV 0.1 KG/CM2
SP 0.1 KG/CM2
Out 0.2 %
BLD PCV PIC01A
34.9 %
QCNRV
BLD STM
2.41 Kg/cm2
6.19 221.46 DegC 219.92 DegC
TPH
7437 RPM
HP GLAND
LP GLAND
BGM
16960.5
51.70 DegC
0.00 DegC
32.08 Kg/cm2
-0.8521 Kg/cm2
51.95 DegC
-0.8700 Kg/cm2
TIE BKR
GEN BKR
TG SYN
OVEF
MAIN OIL TANK
57.38 DegC
42.3 %
HOTWELL
49.6 %
PCV03
10.18 Kg/cm2
332.13 DegC
28.5 %
PCV03BP
-3.0 %
9.82 Kg/cm2
PCV160
0.5 %
0.09 Kg/cm2
PCV161
4.9 %
DM WATER
48.96 DegC
RCV
31.3 %
CST MK UP
13.81 Kg/cm2
38.97 TPH
104PCV01
CSDH VENT CV
SV
PV SV OP FB
PV 62.0 Kg/cm2
SV 61.96 Kg/cm2
OP 0.0 %
FB 0.6 %
MODE
A
M
PCV02
-0.2 %
CEP-1
197.1
DP
CEP-2
DP
360.0
TCV04
-3.1 %
CST
55.27 %
50.21 DegC
CDP-1
CDP-2
DP
EOP501
AOP200
AOP201
ACOP250
ACOP251
23.53 Kg/cm2
TRIP OIL PRESSURE 1.30 Kg/cm2
CONTROL OIL HDR PR. 22.66 Kg/cm2
LUBE OIL HDR PR 2.94 Kg/cm2
LUB OIL TMP AFR CLR 44.91 DegC
ALT COLD AIR TEMP-1 38.01 DegC
LUB OIL FILTER DP 2839.6 MMWC
CONTROL OIL FILTER DP 217.1 MMWC
ACC HDR O/L TMP-1 50.1 DegC
BFP-1
BFP-2
BFP-3
BFP-4
PERM
TEMP
VFD
OP
SPD
CUR
DP
INTIAL
DMTP-1

Case Study – 2 Energy Efficiency
Reduction of Air Ingress into Flue gas by arresting APH Leakages

Air leakage occurs in the APH because of the pressure difference between the high-pressure air and the low pressure exiting flue gases. The air leaks into the flue gas stream and exists to the stack resulting as follows:

- **Energy loss of hot air**
- **Pressure loss of hot air**
- **Additional load on the ID fan**

Result :

The flue gas temperature at the APH outlet increases on account of this besides resulting in reduced boiler efficiency and increased auxiliary power of the fans.

Improvement Measures during shut-down

- **Replacement of worn out seals –radial, axial & bypass**
- **Adjustment of radial sector plates to maintain gap**
- **APH water washing**

Reduction of Air Ingress into Flue gas by arresting

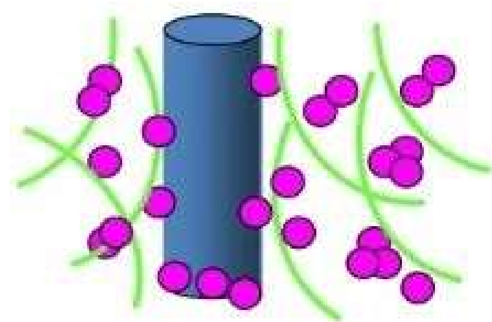
Parameter	Unit	APH A	APH B
Oxygen level at Inlet	%	2.8	3.4
Oxygen level at Outlet	%	4.6	5.1
Air Leakage	%	10.98	10.69
Average Leakage	%	10.83	
Optimum Leakage	%	6.00	
Improvement in Boiler Efficiency	%	0.55	
Coal GCV	kCal/kg	5400	
Annual Coal saving	Tonne	3334.3	
Annual Monetary saving	Rs. Lakh	166.7	
Investment	Rs. Lakh	75.0	
Payback Period	months	5.4	

Case Study – 3 Energy Efficiency
Installation of Sonic soot blowers in place of Steam soot blowers

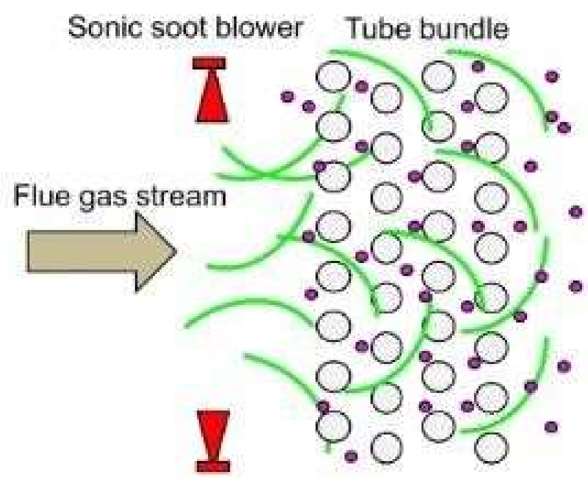
Existing Condition : Air Pre-heater soot blowing is done by steam - Inefficient system

Energy Saving Potential : APH Soot bowing by Sonic Soot Blower results in reduction of steam consumption

Sonic soot blowing is cleaning of fouled surfaces by compressed air operated sonic soot blowers.



Sound waves sent inside boiler propagate in all directions and impart energy to ash particulates which fluidize and jump up from fouled surfaces to be carried away by the flue gas stream.



Cleaning is effective even deep into tube bundles leaving no dead corners unclean.

Parameters	Unit	Operating
Steam consumption in APH Soot Blowing	TPD	17
Steam enthalpy	kCal/kg	766
Annual energy saving	kCal	3904306
Coal GCV	kCal/kg	3400
Annual Coal saving	Tonne	1148
Annual Monetary saving	Rs Lakh	24.1
Additional power consumption with compressor	kW	60
Annual Energy consumption due to compressor	kWh	150000
Annual Monetary for consumption due to compressor	Rs Lakh	1.5
Annual Net Monetary Saving	Rs Lakh	22.6
Investment for Sonic Soot Blowers	Rs Lakh	15
Payback period	months	8.0

Case Study – 4 Energy Efficiency
Stoppage of one Vacuum pump in Unit Normal operation by arresting Air leakages in Condenser system

Existing Condition: In normal plant operation, both vacuum pumps are found I operation to meet vacuum requirement of Condenser

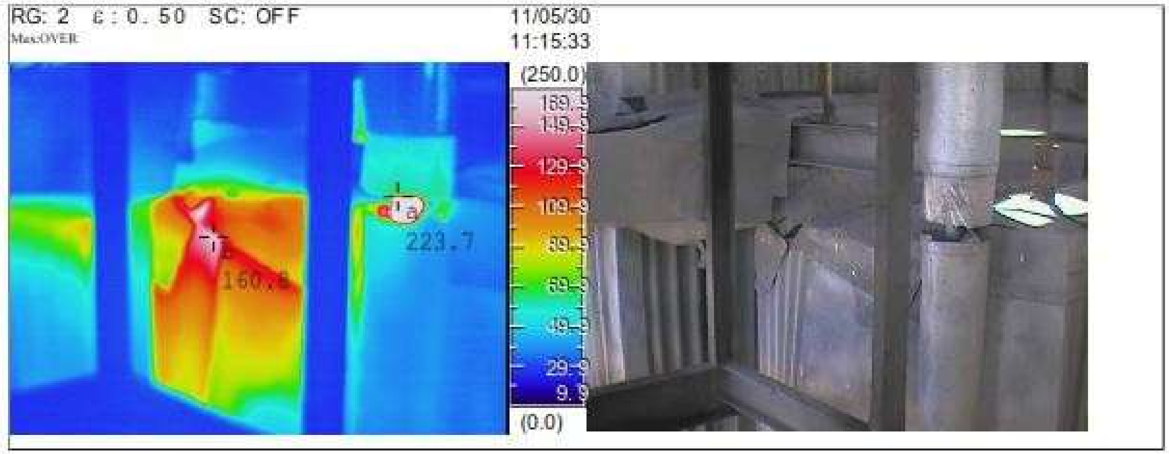
Design Condition : The plant is designed for operating one vacuum pump with one stand by pump.

Type of Condenser	Surface Condenser
No. of Condenser	1
Water Quality	Sea Water
Cooling ater Flow-rate	70000 TPH
Condense Back pressure	76 mmHg-a

- **Performance of Condenser**
- Vacuum is deteriorated due to very high air ingress in Condenser, plant is operating two vacuum pump instead of one pump operation as per design.

Parameter	Unit	Design	Operating
Condenser Duty	kCal/hr	680461505	703212324
Condenser Pressure	mmHg	75.98	92.68
Terminal Temperature Difference	0C	4.06	2.61
Energy Saving Potential			
Power consumption by Vacuum pump	kW	210	210 X 2
Annual Energy consumption	kWh	315000	630000
Annual Monetary saving	Rs. Lakh		6.93
Investment for Air arresting	Rs. Lakh		10.0
Payback period	months		11

Case Study – 5 Energy Efficiency
Proper insulation of Boiler, APH, Economiser & Steam Distribution network ,LP Heaters, HP Heaters, Deaerator

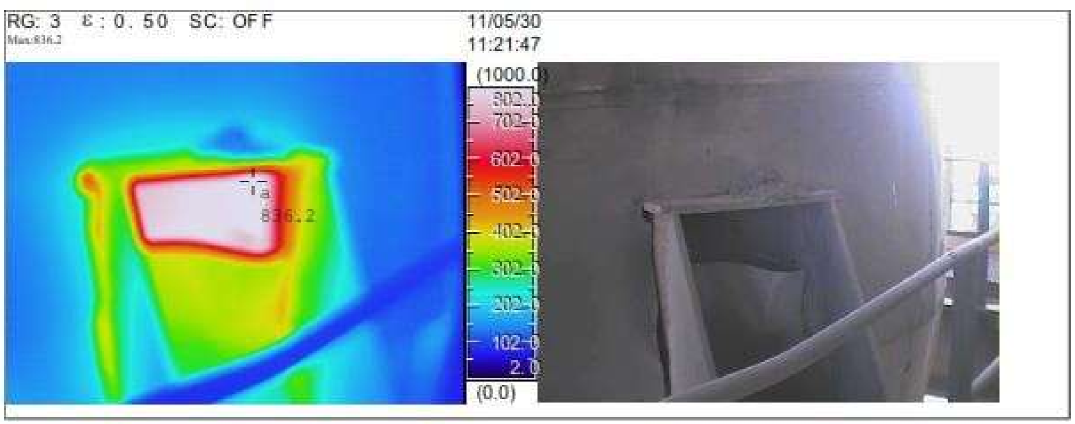


IR Image Information

Visual Image Information

Fig. No. : A 6

Location: Economizer Outlet



IR Image Information

Visual Image Information

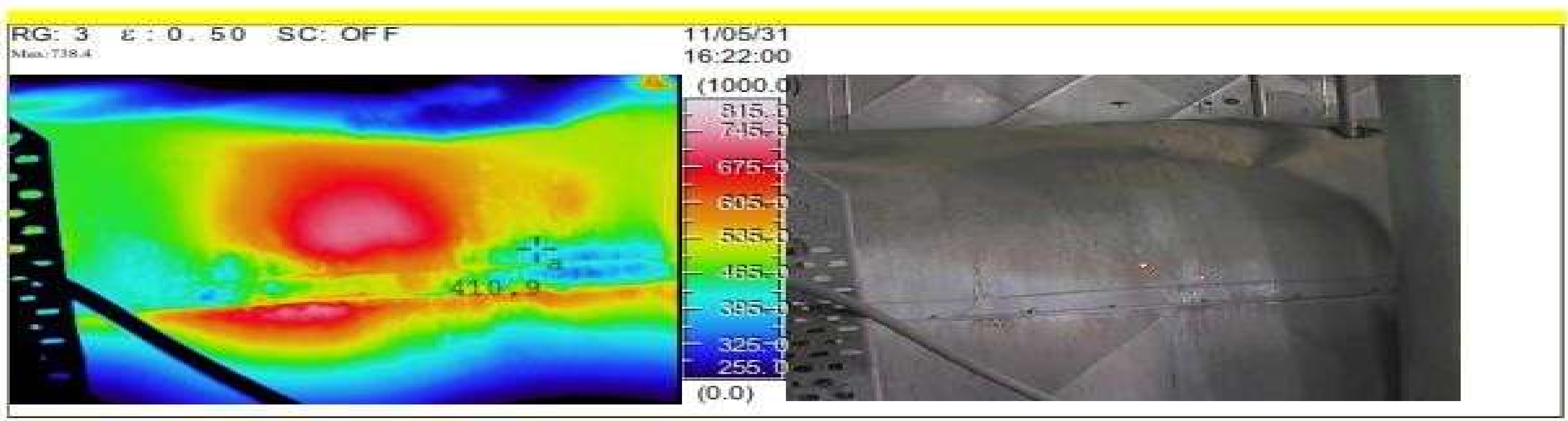
Fig. No. : A 10

Location: After Economizer (3rd Floor)

Hot Insulation Survey by Thermography Camera based on Infrared Radiation Principle To Estimate Heat loss

Case Study – 5 Energy Efficiency
Heat Loss Estimation of uninsulated or weak insulated area of Boiler & Turbine area

Parameter	Unit	Value
Annual Insulation Heat Loss	Lakh kCal	29200
Coal GCV	kCal/kg	5400
Annual Coal saving	Tonne	54100
Annual Monetary saving	Rs. Lakh	27.0
Investment for proper insulation	Rs. Lakh	25.0
Payback period	months	11



Location: –Superheater outlet

THANK YOU