INNOVATIVE ENERGY EFFICIENCY SCHEMES FOR NET HEAT RATE REDUCTION IN CPP IN OPM

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Net Heat Rate Reduction Concept - CPP

- **Gross Heat Rate is direct function of Performance of STG & Boiler**
- **Gross Heat Rate [GHR] = 86000 / Cycle Efficiency**

- **Overall Cycle Efficiency = Boiler η * Turbine η * Generator η**

- **Net Heat Rate is directly related to connected Auxiliary Energy Consumption viz., APC,ASC & IC.**

- **Net Heat Rate [NHR] = Gross Heat Rate [GHR] / [100 – APC]/ 100]**

NHR shall be reduced by :

- **[Effecting GHR reduction]**
- **Lowering APC & ASC as also**
- **Interconnecting [IC] Boiler -Turbine Energy Transfer losses**

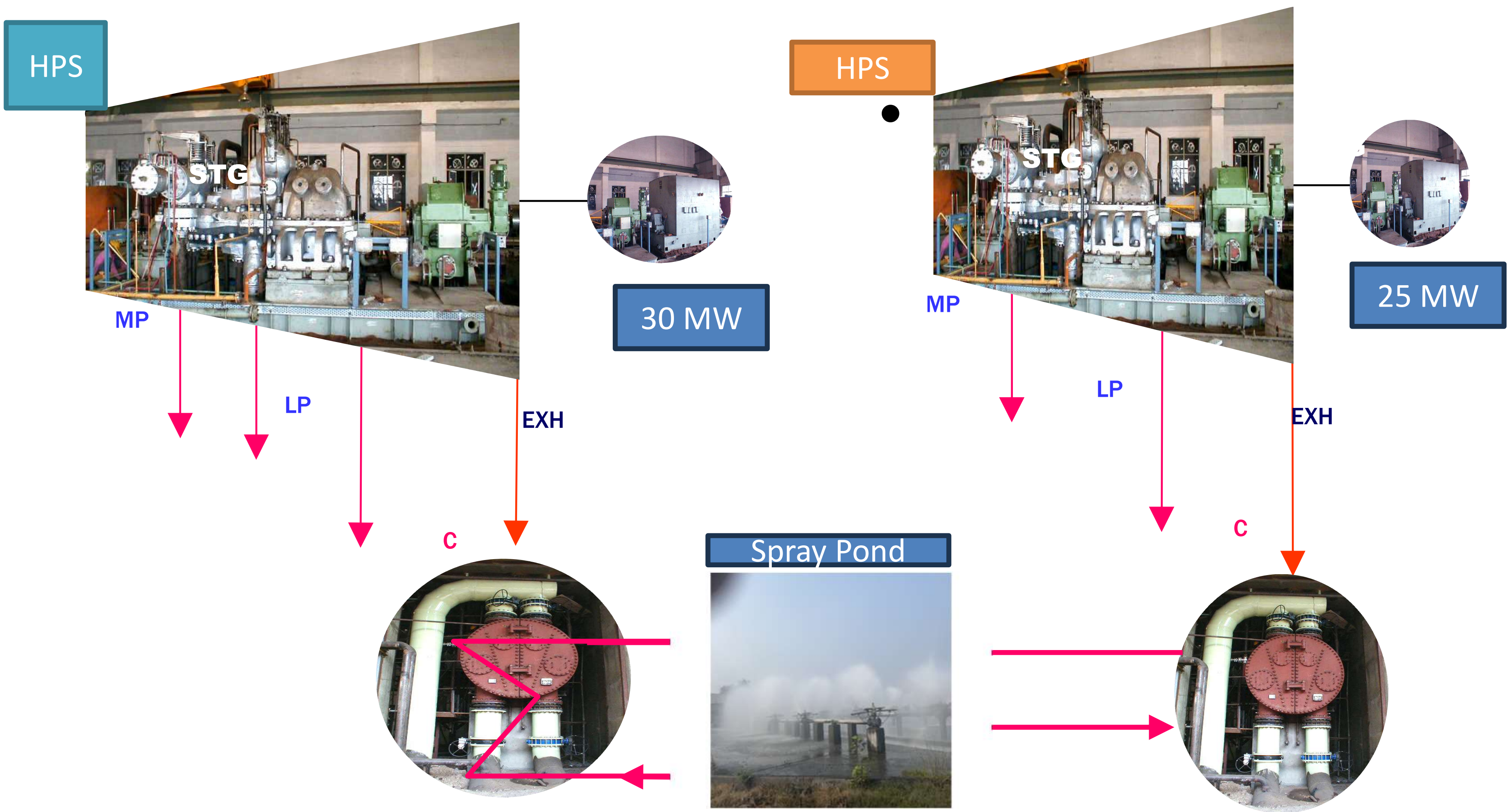
Orient Paper Mills –Amlai is presently having HP Cogeneration Plants in Operation

1 No. 150 TPH AFBC Coal fired Boiler [Steam Pressure /Temperature: 87 ksc/ 510ºC] AFBC Boiler with Feed water temperature at 190ºC connected to 30MW Multi-extraction [MHP, LP, LLP] Condensing [Water cooled condenser] Steam Turbo-Generator.

1 No. 82 TPH Chemical Recovery Boiler [Steam Pressure/Temperature: 64 ksc/ 450ºC] alongwith 90 TPH Stoker Coal fired Boiler connected to 25 MW Multi-Extraction [MP, LP,LLP] Condensing [Water Cooled Condenser] Steam Turbo-Generator.

Both condensers are related to cooling water in closed circulation connected to a Common Spray Pond.

AFBCB & CRB HP COGEN BATTERY IN OPM



INNOVATIVE ECS # 1 FOR NHR REDUCTION

CONCEPT OF VARYING COOLING WATER FLOW IN CONDENSERS FOR NET POWER ENHANCEMENT

CW Pumps Power Optimization with Both Extraction Condensing STGs in operation

STANDARD PRACTICE IN ALL STEAM TURBINES WITH CONDENSERS

Constant Cooling water flow rate designed for Rated Condensation (max.) flow is being maintained all along –irrespective of exhaust steam condensing flows.

Cooling water Pump(s) hence are designed for maximum condensing flows with design margin on flow & head necessitating constant high auxiliary Power Consumption at all [Low/Medium /High] Condensing loads of operation.

INNOVATIVE ECS FORMULATION & IMPLEMENTATION

Innovative energy scheme had been developed for adjusting cooling water loads to suit varied condensing flows . Hence it was proposed to reduce the circulating cooling water load to condenser at lower condensing loads to suit. This has in principle approval & acceptance of Siemens.

Hence cooling water flow to condensers shall be lowered at lowered condensing loads for effecting reduction in MCW Pump power consumption [APC].

High APC of CW Pumps in [Extraction] Condensing STG Battery

- Exhaust Steam Condensing Flows are being split between the 2 Steam Turbines

- Constant flows [designed for rated condensation] in both the Condensers irrespective of condensing flows

- **Invariably in Cogen units, Extraction steam for process is very high with balance only for condensing steam**

- APC Very High at 1.05 MW with 2 CW pumps in operation even with Condensing flows < 50 % of rated value.

- Moreover, the CW Pumps had been designed for 1.3 times Design load.

CW Pumps Optimization with Both Extraction Condensing STGs in operation

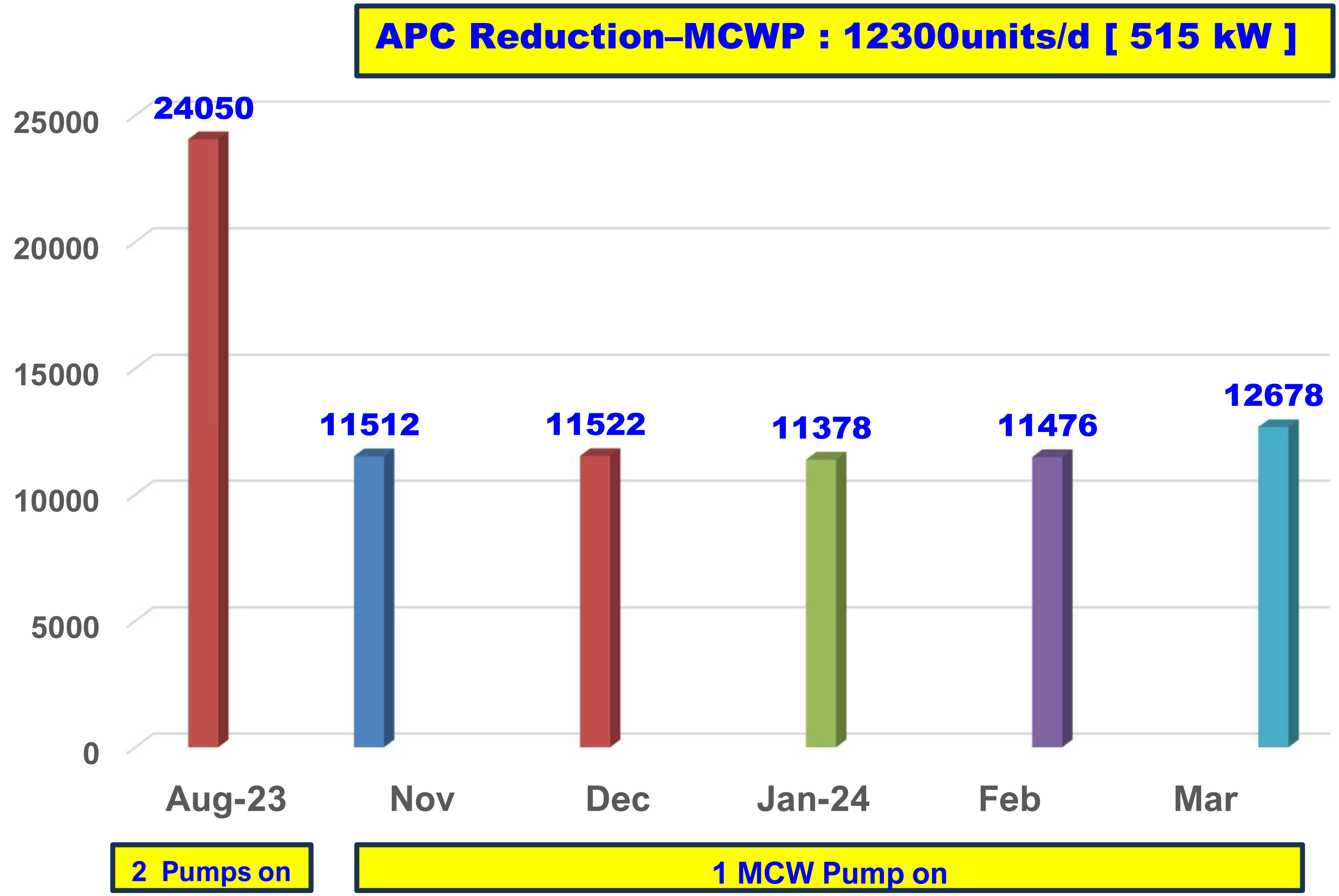
EARLIER

2 CW pumps of very high flow rate [5300 m3/h each] had been in operation all along. As the requirement of CW flows for the 2 Condensers are far less [~3800 m3/h] even at rated high condensing loads of 57 to 64 TPH, Power consumption is uniformly high at around 1.0 to 1.1 MW.

RECOMMENDATORY ADVISE & PRACTICE

It was decided to put in practice the innovative concept of varying the cooling water flow to condenser as under :
As the condensing loads in each of the turbines are very low viz., 25 to 30 TPH, it had been decided to operate 1 CW pump catering water flows to both the condensers.[As & when the condensing loads go up > 30/35 TPH on a sustained period, both the CW pumps need to be operated].

REDUCTION IN APC WITH 1 of 2 MCW PUMPS OFF



Innovative Concept of Varying Cooling water flow with Condensing Loads

PLANNED –TAKING THE CONCEPT FURTHER

- **New Energy Efficient lower duty CW pumps [200 kW] one with Fixed speed & the other with Varying speed alongwith IE3/IE4 motors. The proposed cooling water pump shall be with VFD so as to vary the cooling water flow to condenser to suit the varying condensing steam flows. Through this process, APC from CW pump(s) shall be lowered-resulting in increase in net power available for process.**
- **Though Cooling water flow through the condenser tubes had been designed for exhaust steam condensation rated capacity, the CW flow rate shall be reduced suitably with lowered condensing loads with Varying speed of the 2nd CW pump in operation.**
- **APC is expected to be reduced further by 100 to 150 kW**
- **Net Heat rate reduction is ensured.**

ENERGY GAINS & DECARBONIZATION

APC reduction & Net Heat Rate Improvement

Reduction in CW pump power consumption …………………………….. : 0.515 [+0.15] MW

Reduction in APC achieved/planned is of the order of ……………………………….: 2.5 %

[0.65 MW out of ~24 to 26 MW total power generation].

Alongside Turbine Net Heat Rate shall be lowered by ……………………………….: ~ 2.5 %.

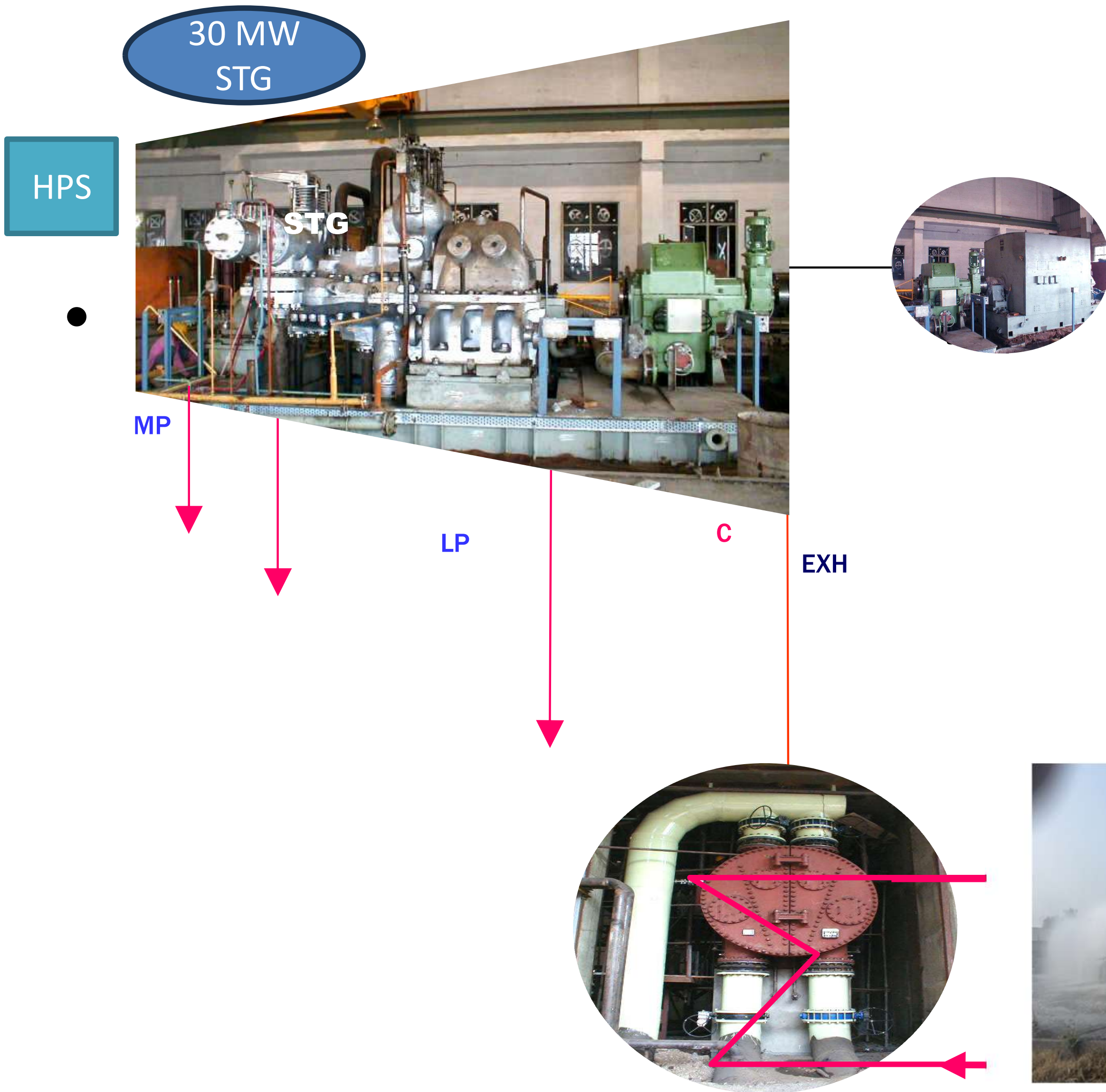
Carbon Emission Reduction

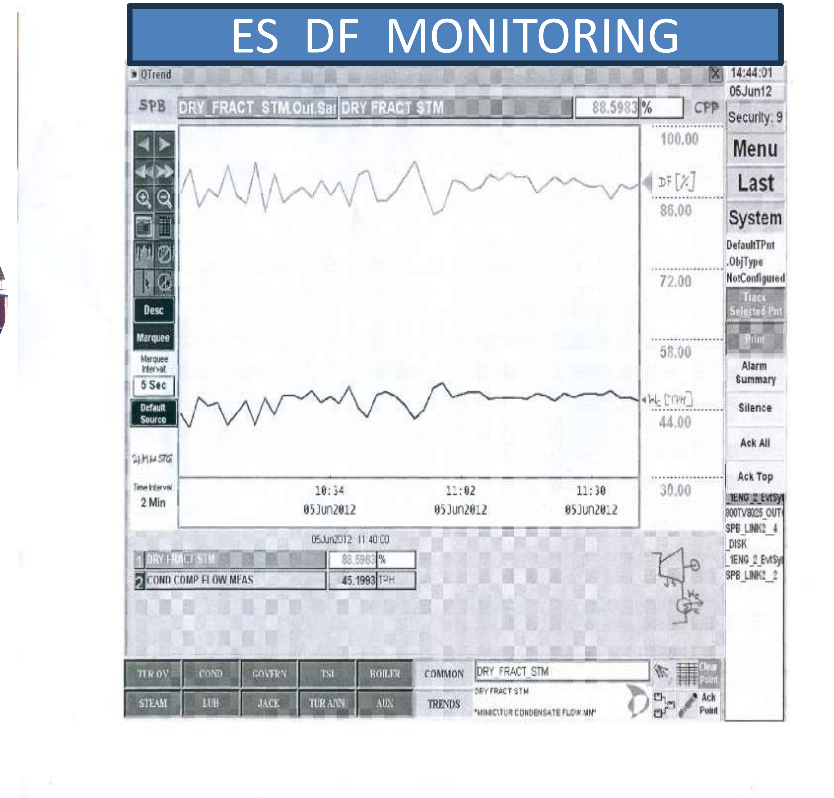
Existing [Planned]

Through effecting power consumption reduction of ………: 12380 [+3600] units/day ,

Carbon Emission Reduction accrued is …………………..:~ 500 [+150] tCO2e/month .

MULTI-EXTRACTION CONDENSING STG

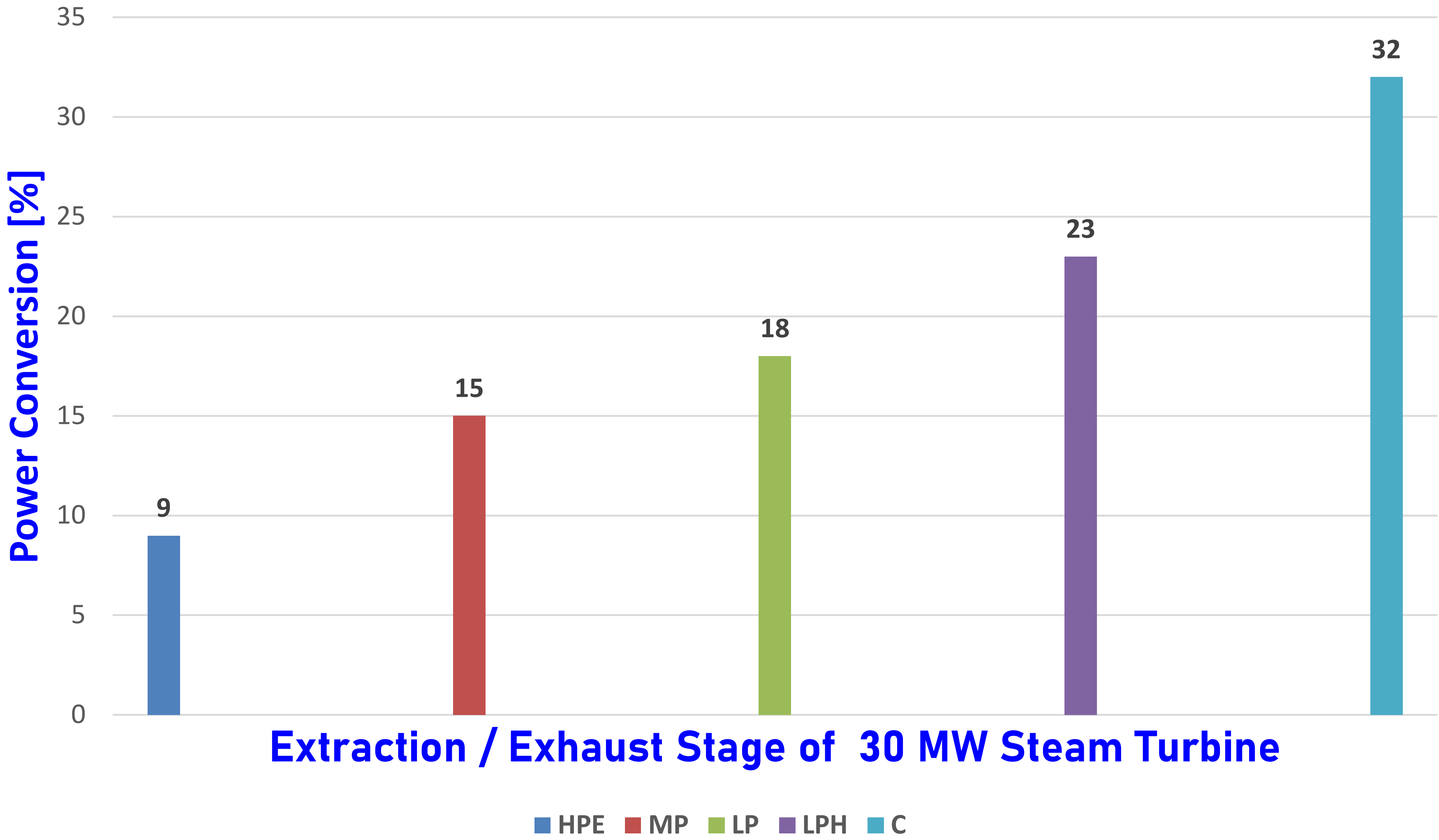




HEAT RATE & CYCLE EFFICIENCY– 30 MW STG - ILLUSTRATION

	Parameter	Flow	Pressure	Temperature	Enthalpy	Energy
		TPH	ksca	Deg C	Kcal/kg	MKcal/h
A	HPS in	143.9	84	505	814	117.13
B	HMP Ext1	30.54	20.81	338	743	21.68
C	LP Ext 2	64.26	5.0	181	672	43.18
D	LLP Ext 3	4.4	1.14	102	626	2.75
E	Exh-Condsn	44.7	0.091	44	44	1.97
F	Power Output					25.65 MW
	GHR =	[A-(B+C+D+E)]/F		1850	Kcal/kWh	
	Cycle Effy	86000/GHR		47	%	

STEAM TURBINE EXTRACTION/EXHAUST ON HEAT RATE



INNOVATIVE METHODOLOGY FOR SUSTAINED HEAT RATE IMPROVEMENT

- **Turbine exhaust steam flow, Vacuum, Cooling water flow rate alongwith inlet & outlet temperatures to 30 MW STG Condenser shall be measured with on-line temperature sensors on line & transferred to DCS for continuous recording.**
- **Exhaust steam condensing flow rate is already being measured with vacuum on a continuous basis.**
- **With all of the above in place, turbine exhaust steam enthalpy shall be computed [with the developed Innovative Algorithm].**
- **Exhaust steam enthalpy shall be Dovetailed with CW flow of MCW Pump.**

INNOVATIVE METHODOLOGY FOR SUSTAINED HEAT RATE IMPROVEMENT

- **Cooling water flow rate shall be adjusted with VFD of CW pump relating to NHR reduction & minimize exhaust steam enthalpy with Condenser vacuum subject to dryness fraction limit set at 0.88-0.89 [using Generative AI tool].**

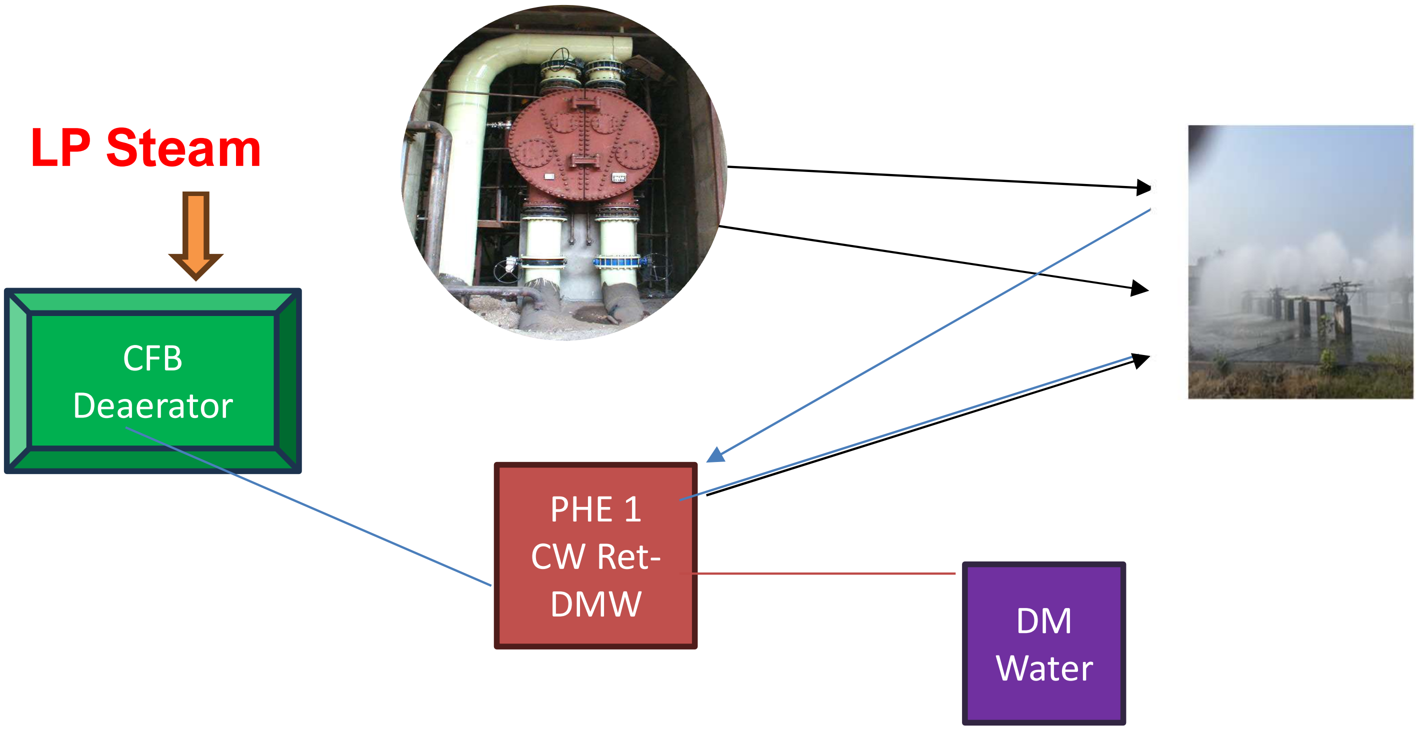
- **Integrating Steam inlet conditions with the above, Objective is to maximize steam enthalpy difference between Turbine inlet & exhaust & thereby maximize Power generation.**

- **Plan to use IoT 5.0 concept through ensuring sustained uniform operation especially during change of shift.**

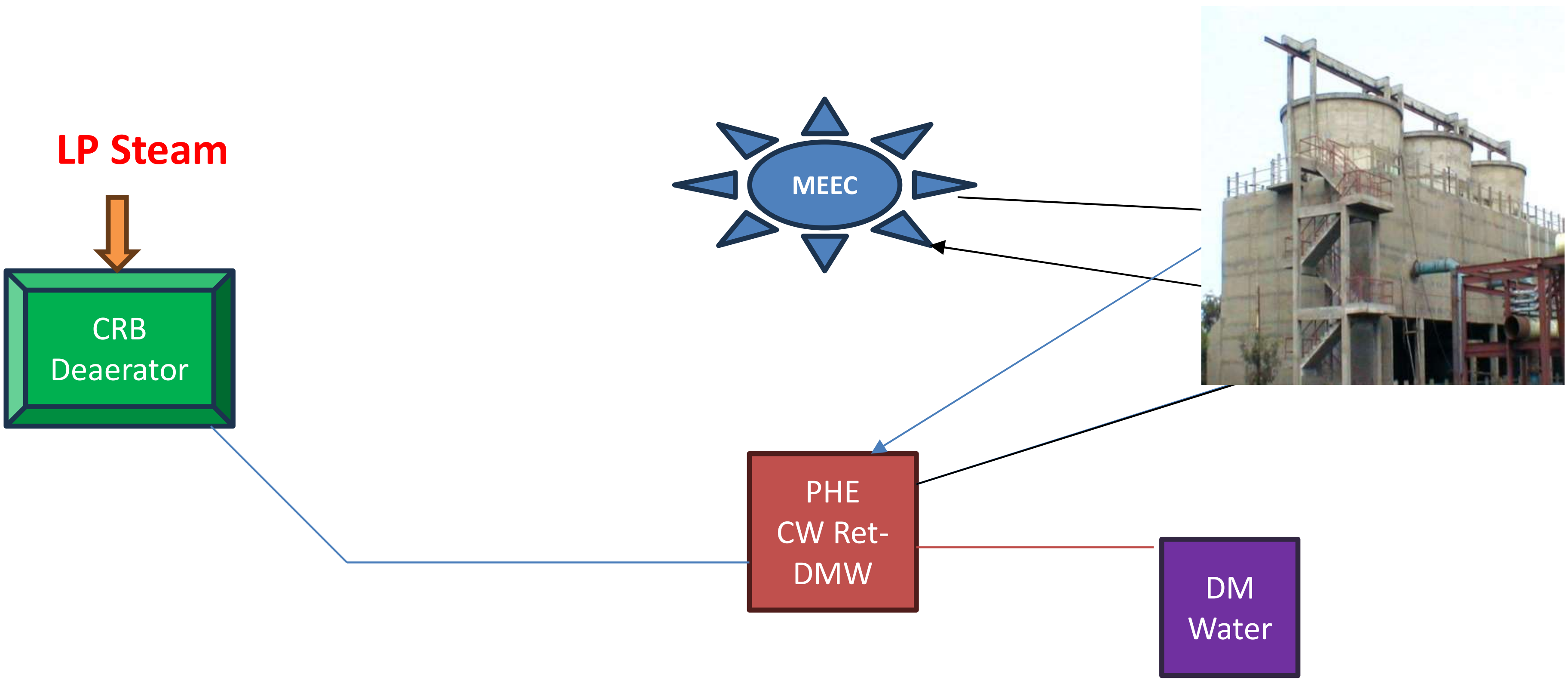
INNOVATIVE ECS # 2 FOR NHR REDUCTION

Waste Heat from Condenser lukewarm water discharge for preheating Boiler make-up water-
Deaerator Steam Consumption Reduction

STG Condenser Lukewarm Cw return for preheating DM Water



MEE Cw Cdsr return [Cooling tower divert] preheating DM Water



Impact of Wide Seasonal Temperature range related to LPS saving with heat in warm water return from Condensers

Coal Fired Boiler

DM Water Flow : 20 m3/h					
Season		Winter		Summer	
Time		Day	Night	Day	Night
DM Water Temp.	°C	20-24	16-20	29-32	26-29
LPS Saving-Deaer	TPH	0.45	0.6	0.3	0.4
Temp. range	°C	16-24		26-32	
CER	tCO_2e /month	120		80	

Chemical Recovery Boiler

DM Water Flow : 50 m3/h					
Season		Winter		Summer	
Time		Day	Night	Day	Night
DM Water Temp.	°C	20-24	16-20	29-32	26-29
LPS Saving -Deaer	TPH	1.1	1.5	0.75	1.0
Temp. range		16-24		26-32	
CER	tCO_2e /month	200		300	

With PHE installation, DM water Pump pressure had been reduced with VFD from …………………………..: 12 ksc to 5 ksc.

DM Water Flow Rate………………………..: 45 to 50 m3/h

Power Consumption reduction …………...: 15 kW.[0.015 MW]

Green Power increase ……………………..: ~360 units/day

Emission reduction credit …………………: 120 tCO_2e/yr

Reduction in Absolute Stack Pollutants discharge : Traces

With PHE installation, DM water Pump pressure shall be reduced with VFD from ………………………..: 12 ksc to 5 ksc.

DM Water Flow Rate………………………..: 15 to 20 m3/h

Power Consumption reduction …………...: ~8 kW.[~0.01 MW]

Green Power increase ……………………..: ~200 units/day

Emission reduction credit …………………: 70 tCO_2e/yr

Reduction in Absolute Stack Pollutants discharge : Traces

ENERGY GAINS & DECARBONIZATION

ASC +APC Reduction & Net Heat Rate Improvement

Reduction in LP Steam Consumption in Deaerators .. : 1.1 TPH+ 0.4 TPH

Reduction in ASC achieved/planned is of the order of ....: 0.3%

[1.5 TPH LPS out of 250/300 TPH HP steam].

Reduction in both DM water pumps power consumption : 15 +8 = 23 kW

Reduction in APC achieved/planned is of the order of ....: 0.1%

[23 kW of 25 MW].

Overall Turbine Net Heat Rate shall be lowered by ....: ~0.4 %.

Carbon Emission Reduction -Existing & [Planned]

Carbon Emission Reduction Accrual ....:~ 3600 tCO_2e/yr .

NET ENERGY AVAILABLE & NOT GROSS ENERGY GENERATION
OTHERS

APC

Centre	Unit	Reduction Scheme
Boiler	BFP	• High η [77%]with Low DP CV
Boiler	Fans	• High η [> 80%] with/without VFD
Boiler	ESP	• Energy efficient Transformers, • Design & Optimization of rapping
CPP	Air Compressor	• Waste heat[80%] to Steam for Power gen.
STG	CW Pump	• Avoid CV throttling & High η CWP [>86%]+Optimization

NPA = Power Gen[GP]- APC

ASC

Centre	Unit	Reduction Scheme
Boiler	Deaerator	• Hot Process Condensate return total & • Hot Condensate Polishing
Boiler	SCAPH	• Optimizn of Steam pressures, • Condensate air heating & • Effective Insulation
Boiler	Blow-down & Leaks	• Minimization & Avoidance
Boiler	Soot-blowing	• Optimization & • HPS fm Blr to MPS from ST
STG	Generator Air Cooler	• CW to DM water & • Turbine return condensate

NSA= Gross Steam Gen- ASC

NHR –APC+ASC- Reduction Tips

- Feed water temperature increase due to Pressure rise in BFP increasing steam economy
- In duct Combustion Air drawl increases combustion air temperature
- Low DP Control Valve relates to lowered BFP Power consumption
- CBD reduction –Advanced Boiler water conditioning
- Boiler –Turbine Interconnection Pipe Insulation strengthening to minimize steam temperature drop
- Generator Air Cooling with Boiler make-up water & turbine condensate
- CPP Air Compressor- Waste heat recovery -Boiler make-up water heating

CONCLUSIONS & ADVISORY

INNOVATIVE ECS # 01 [APC-Redn.]

With Cooling water flow lowered distribution in the 2 Condensers, through stoppage & running of 1 of 2 CW Pumps, significant APC reduction/Energy savings are being accrued on a sustained basis.

With this demonstration, stage is now set for varying the cooling water flow in line with varied turbine exhaust steam condensing flow by going in for proposed Energy efficient smaller CWP with VFD alongwith existing MCW Pump in place. With VFD in place, reduction in MCW Pump Power shall be ensured at all condensing loads –high [35 to 50 TPH], medium [30 to 35 TPH & low [20 to 30 TPH].

Recommendation is one of varying Cooling water flow with condensation steam rate, CW conditions [ambient], condenser exhaust steam state , so as to minimize ST exhaust steam enthalpy so as to reduce NHR on a sustained basis.

INNOVATIVE ECS # 02 [ASC –Redn.]

Diverting partly waste lukewarm water from Turbine Condenser & MEE Condenser outlet for preheating DM feed water through PHEs, Steam consumption is being/shall be reduced in both the Deaerators- more so during Winter Season as compared to Summer.

Both of the above Innovative ECS contribute to reduction in NHR of CPP complex; The schemes can be replicated in all CPP/TPP so as to achieve NHR reduction on a continuous basis.