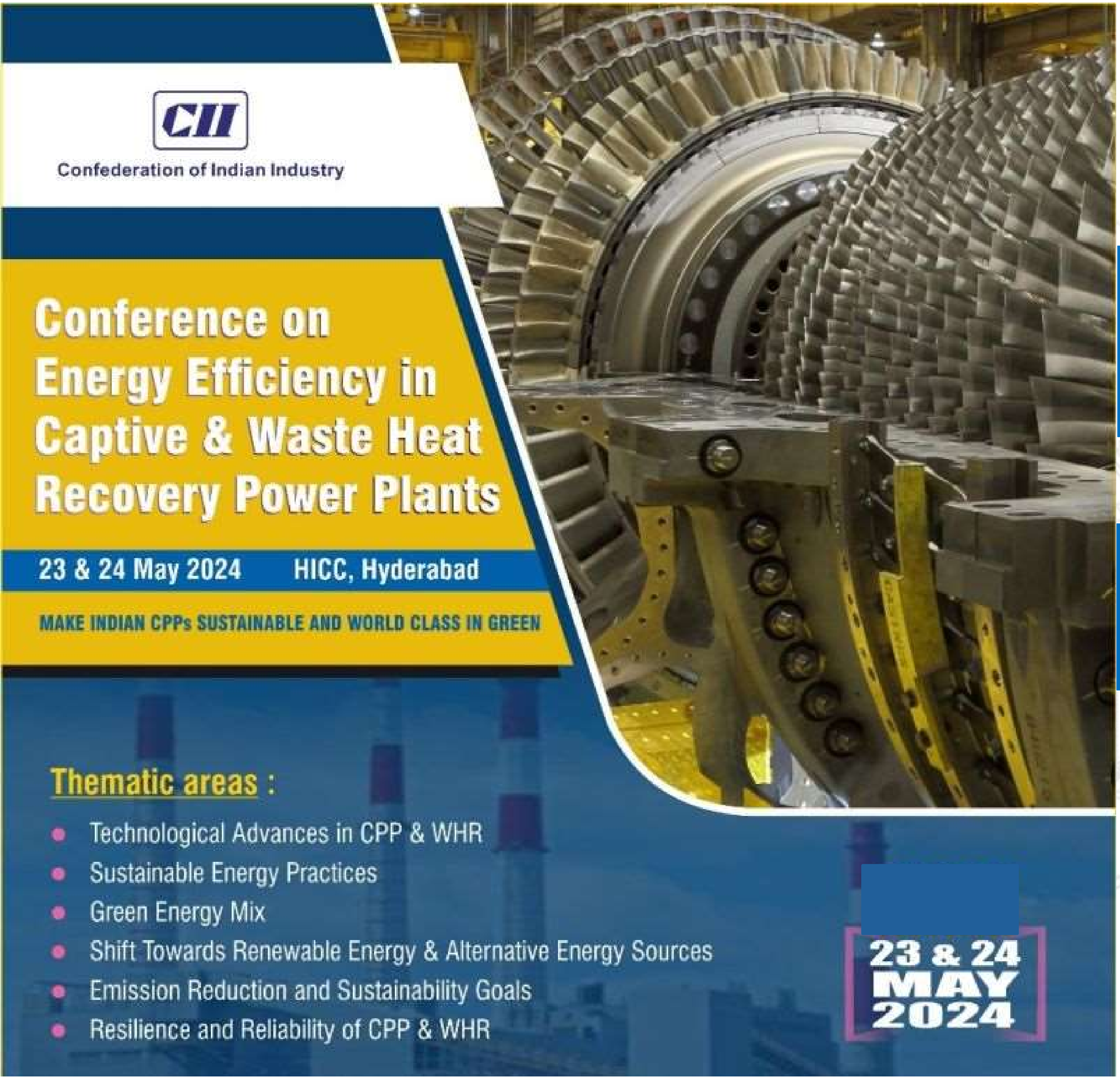

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Confederation of Indian Industry

Best Practices in Captive Power Plants

23 & 24 May 2024
HICC, Hyderabad

CII – Godrej Green Business Centre

CII – Green Business Centre, Hyderabad

- India’s first Platinum rated **Net-Zero building**
- Use **bi-facial solar panels** – generating 10% more than demand

Key Activities

- 10.26 billion ft^2 of Green Buildings
- 2nd Largest footprint in the world
- 92% of Green Building Footprint in the country

- First of its kind in the world
- > 1000 companies involved
- USD 400 million annual recurring savings

- 6,400 + green products certified
- >90% of Building Materials are under GreenPro

- 2,000+ energy audits and largest energy auditors
- 100+ projects in energy efficiency, climate mitigation and RE

- Accelerating the growth of innovative Clean Technology startups
- > 25 Startups part of cohort

Overview of Indian Captive Power Plant

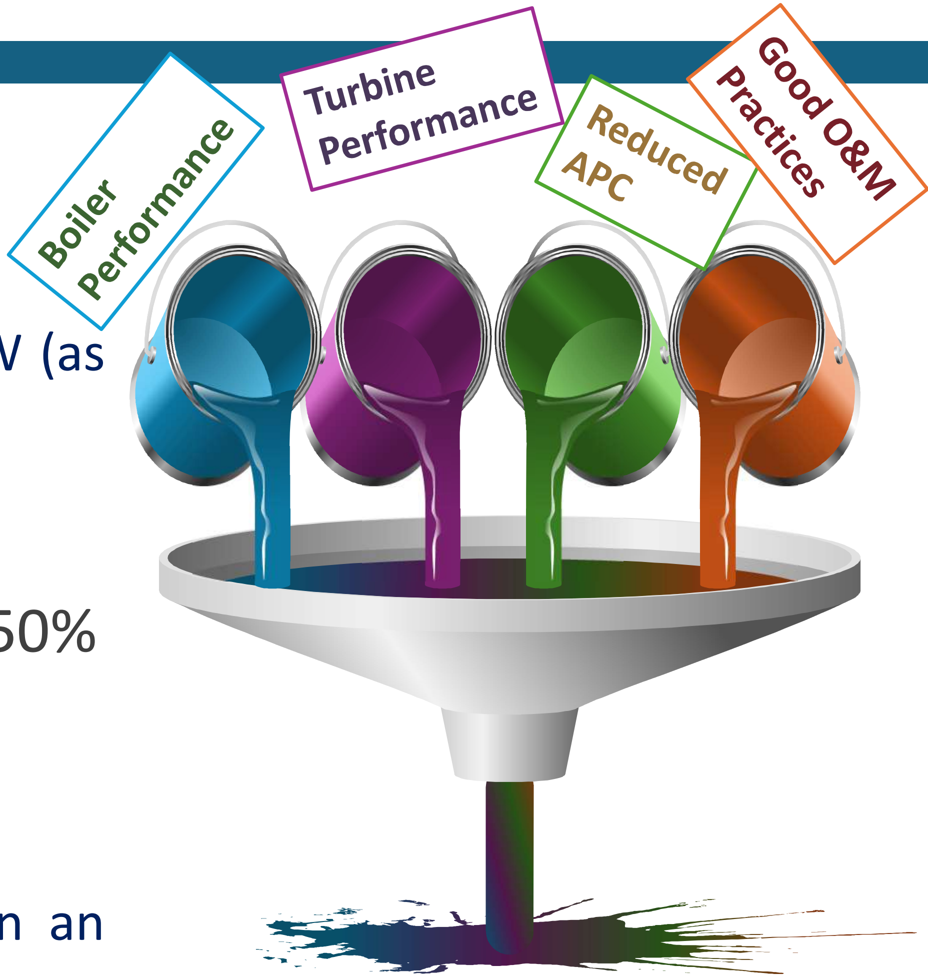
Importance of Energy Efficiency in Captive Power Plants

India's Total Installed Capacity–399.496 GW (excluding CPPs)

- Total Installed Capacity of CPPs in India – 78.508 GW (as of March 2021)
  - Equal to 19% of total installed power in India

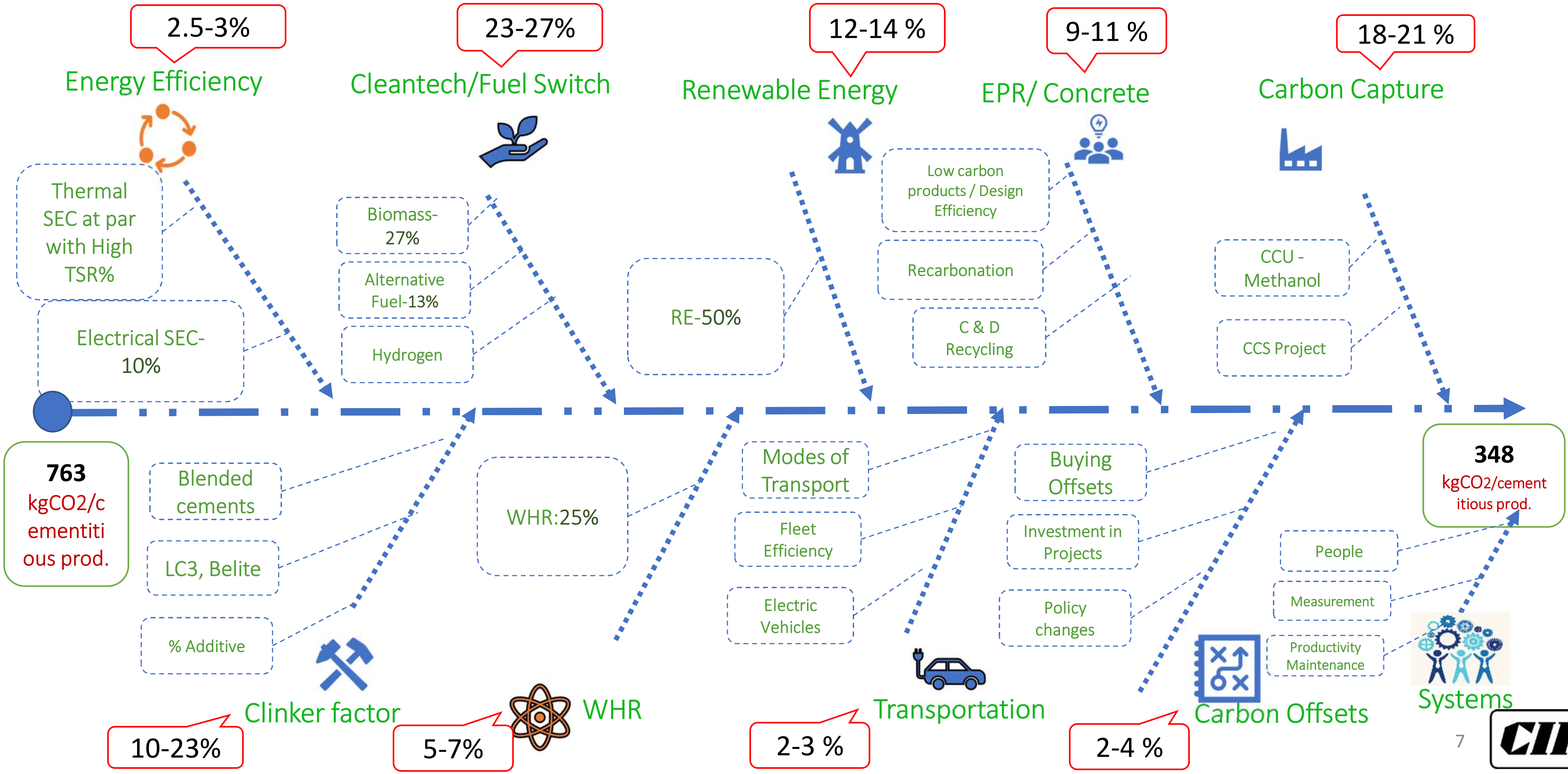
Considering an average gross heat rate of 3208, 50% coal based, PLF of 50%, GCV – 3500 kCal/Kg

- Annual Coal Consumption ~ 100 million tons
- 1 % improvement in net heat rate would result in an annual savings of 1 million tons of coal consumption



Efficient Captive Power Plant

Deep Decarbonization Roadmap-2MTPA model Cement Plant



Benchmarking of Performance Parameters of 15 MW

Sl. No	Parameters	UOM	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 6
1	Installed Capacity	MW	15	15	17.5	15.7	17.5	18
2	Type		AFBC	AFBC	AFBC	AFBC	AFBC	AFBC
3	PLF	%	82.3	65	84	71	77.8	84.05
4	Heat Rate	Kcal/Kwh	3250.3	3348	3018	3065	3035	3161
5	APC	%	7.97	9.1	9.3	8.52	9.69	7.5
6	Coal GCV	Kcal/Kg	5268.8	4062	3213		3175	

Benchmarking of Performance Parameters of 25 MW

Sl. No.	Parameters	UOM	Plant 1	Plant 2	Plant 3
1	Installed Capacity	MW	2 x 25	2 x 23	2 x 23
2	Type		CFBC	CFBC	CFBC
3	PLF	%	97.4	75.41	77.71
4	Heat Rate	Kcal/Kwh	2932	3036	2968
5	APC	%	9.51	9.54	11.78
6	Coal GCV	Kcal/Kg	6475		

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Equipment Wise Benchmarking of Major Equipment's

Equipment Wise Benchmarking of Major Equipments		
Sr. No.	Parameters	Country Best
	UOM	KW/MW
1	Boiler Feed Pump	15.58
2	ID Fans	1.73
3	PA Fans	2.58
4	FD / SA Fans	11.18 / 10.61
6	CWP	14.59
7	CEP	1.17
8	ACW	1.43
9	Compressors	2.84

10	Instrument Air Pr	5 Kg/cm^2
11	Service Air Pr	2.35 Kg/cm^2

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Best Practices in Captive Power Plant & WHRS

1. MOV in BFP ARC Line for Avoiding Recirculation

❖ Observation:

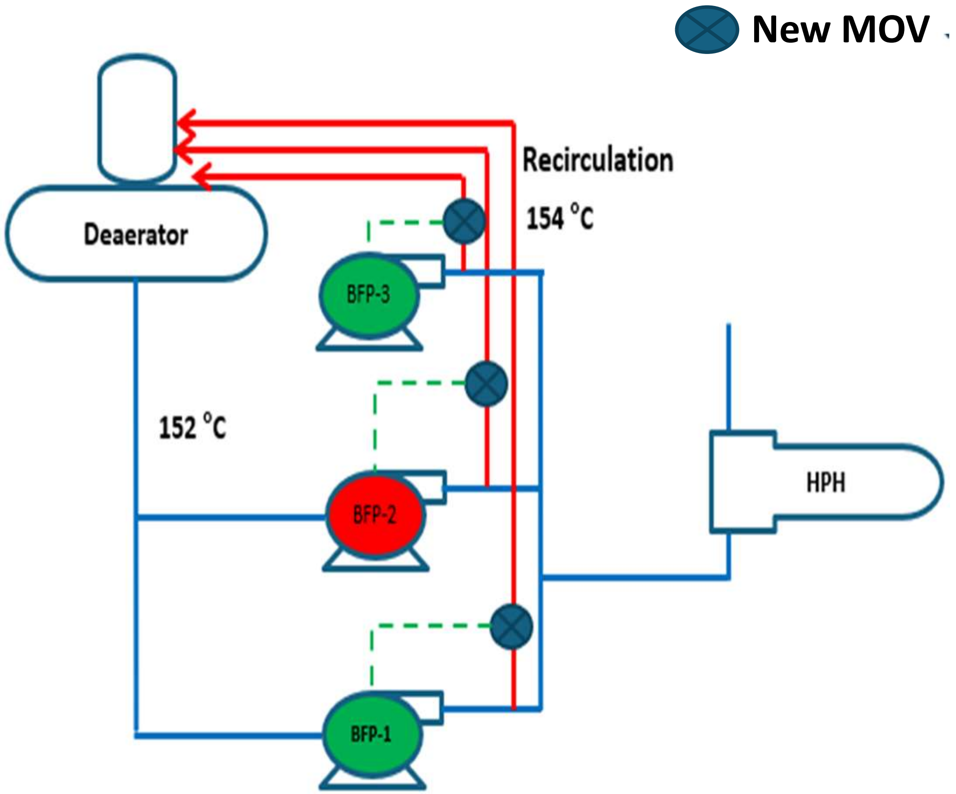
✓Three feed water pumps installed

◦ Two pumps are running & one pump stand by mode for the operating load

✓BFP Recirculation valve found to be passing

◦ Power loss due to recirculation of water

◦ Potential to save power by maintenance / replace of ARC valve



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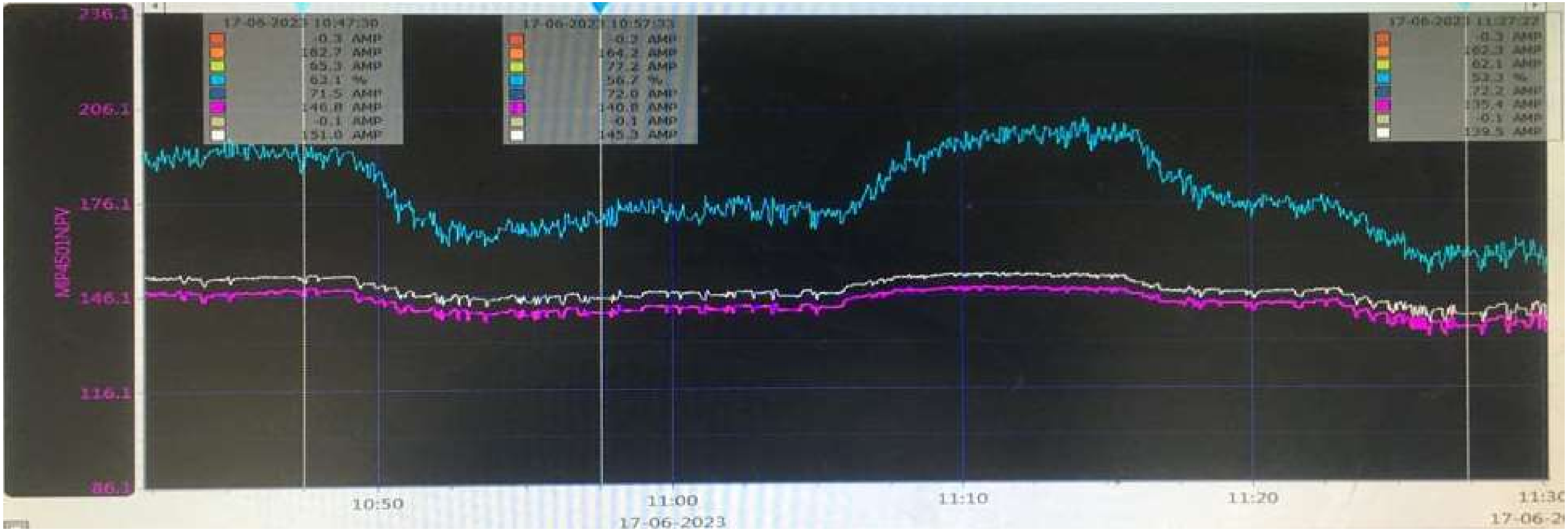
❖ Trail with manual isolation valve open/close condition

Manual Isolation Valve position		Time	BFP 1 current (amp)	BFP 2 current (amp)	FCV %	Pump power (kW)
BFP 1	**BFP 3**					
Open	Open	10:47	148.3	152.6	64.0	1747
Close	Open	10:59	142.7	147.4	58.3	1684
Close	Close	11:27	135.4	139.5	53.3	1596
					Diff	**151**


236.1
206.1
176.1
146.1
116.1
86.1
MP4501NPV
17-06-2023 10:47:30
-0.3 AMP
182.7 AMP
65.3 AMP
63.1 %
71.5 AMP
146.8 AMP
-0.1 AMP
151.0 AMP
17-06-2023 10:57:33
-0.2 AMP
164.2 AMP
77.2 AMP
56.7 %
72.0 AMP
140.8 AMP
-0.1 AMP
145.3 AMP
17-06-2023 11:27:22
-0.3 AMP
162.3 AMP
62.1 AMP
53.3 %
72.2 AMP
135.4 AMP
-0.1 AMP
139.5 AMP
10:50
11:00
17-06-2023
11:10
11:20

❖ MOV Installation at other units

Recommendation

- Possible reason for passing in the recirculation line
  - Chances of wear out of the valve during operation
  - Over a period, the opening percentage increases during full valve close condition and Increases the recirculation quantity
- Install MOV after the Manual isolation valve
- Interlock the MOV with BFP pressure, flow & speed (Suitable protection logic)

Saving potential

- 9% recirculation is observed, and savings are estimated
  - 150 kW (Considering 2 pumps)

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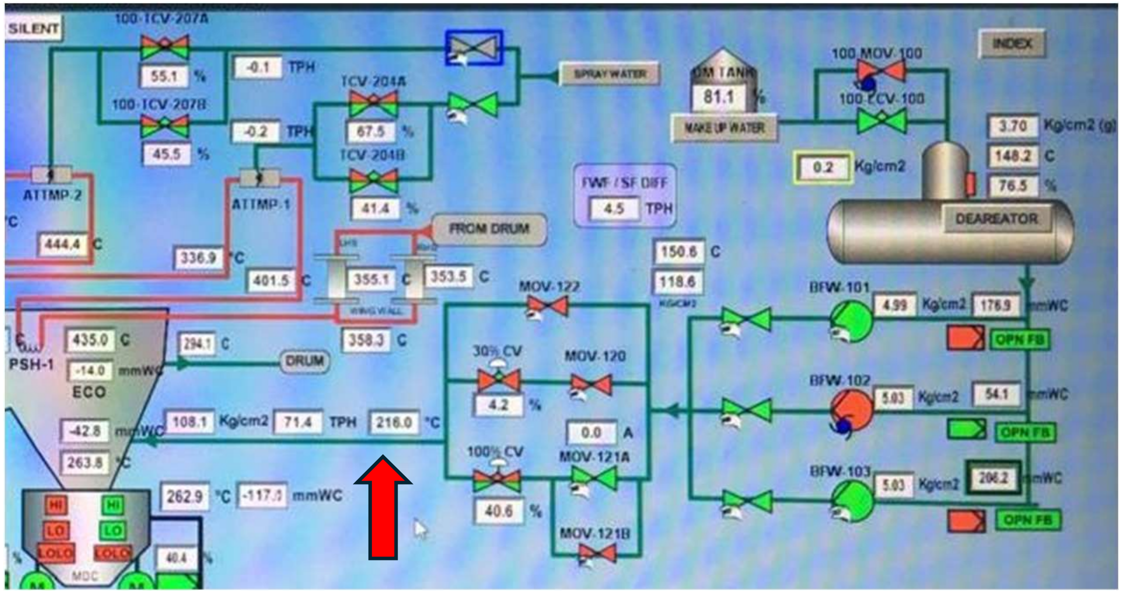
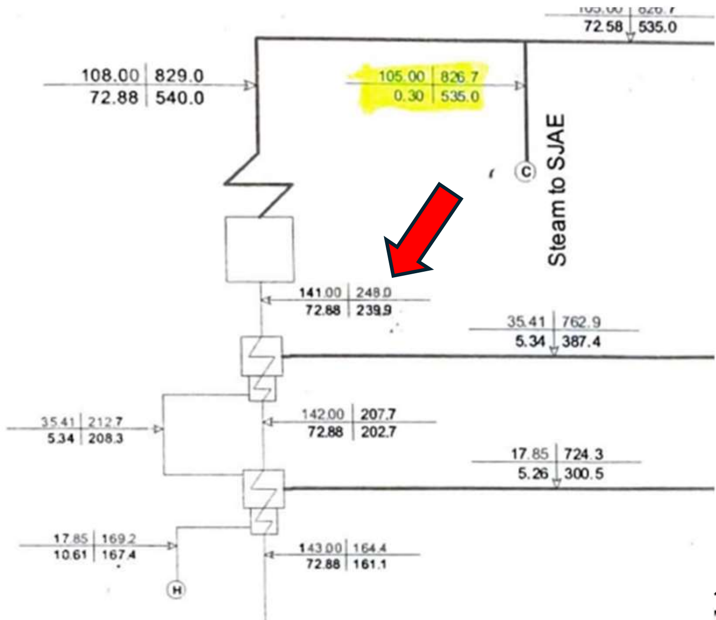
2. Increase the Boiler Feed Water Temperature and Operate as per HMBD

Observations

- Presently turbine is running at 17 to 18 MW load
- The feed water temperature at HPH-2 outlet is 214 deg c
- As per HMBD the HPH-2 feed water outlet temperature is 240 deg c





Observations

- **The HPH-1 & 2 extraction steam line MOV found to be throttled considering high specific steam consumption**
- **However, the heat rate is found to be high**

SI.NO	DESCRIPTION	UOM	ACTUAL	DESIGN		REMARKS
1	**HP heater 2 o/l FW Temperature**	**Deg C**	**216**	**239.9**		**From DCS**
2	**HPH 2 flow**	**TPH**	**3.5**	**5.4**		**Auto calculated**
3	TTD	Deg C	33.0	3.3		**Auto calculated**
4	DCA	Deg C	7.4	5.6		**Auto calculated**
5	FW temp rise	Deg C	26.3	37.2		**Auto calculated**
1	**HP heater 1 o/l FW Temperature**	**Deg C**	**189.7**	**202.7**		**From DCS**
2	**HPH 1 flow**	**TPH**	**4.7**	**5.2**		**Auto calculated**
3	TTD	Deg C	23.9	4.0		Auto calculated
4	DCA	Deg C	10.8	8.7		Auto calculated
5	FW temp rise	Deg C	41.5	44.0		Auto calculated

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Observations

S.no	Condition	TG load	MS flow	MS temp	FW temp	THR	Sp steam cons	Blr eff	GHR	Fuel GCV	Fuel cons
		MW	TPH	deg c	deg c	kcal/kW	kg/kW	%	kcal/kW	kcal/kg	MT
1	100 TMCR	18	72.88	535	239.9	2342.3	4.05	89.5	2617.1	5700	8.26
2	HPH-2 out	18	69.57	535	205	2382.4	3.87	89.5	2661.9	5700	8.41
3	HPH-1 out	18	73.02	535	235.2	2367.9	4.06	89.5	2645.7	5700	8.35
4	LPH out	18	73.99	535	240.5	2375.2	4.11	89.5	2653.9	5700	8.38

- **As per HMBD analysis, if the HP heater is out**
  - **The specific steam consumption decreases**
  - **The heat rate increases**
- **More the steam drawn**
  - **higher the feed water temperature**
  - **Lesser the latent heat loss in the condenser**

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Recommendation

- Increase the feed water temperature by
  - maintaining the deaerator pressure as per HMBD
  - Reducing the throttling of MOV in the extraction steam line
- Maintain the feed water temperature as per HMBD
- Heat rate saving potential - Expected
  - 26 kcal/kW

		Present	Proposed
HPH-1 inlet temp	Deg c	148.2	158.7
HPH-1 outlet temp	Deg c	189.7	202.7
HPH-2 inlet temp	Deg c	189.7	202.7
HPH-2 outlet temp	**Deg c**	**216**	**239.9**
Additional steam flow req in HPH-1	TPH		1.6
Additional steam flow req in HPH-2	TPH		1.38
Additional MS steam flow req	TPH		2.2
MS steam flow	**TPH**	**71.9**	**74.2**
THR	**Kcal/kW**	**2565**	**2530**

3. Energy Efficient Boiler Feed Water Pump

Observation:

- Three feed water pumps are installed (2W + 1S)
- The design efficiency of the pump is 62.2%
- Rated power is 508 kW for a flow rate of 83.75 m3/hr
- Pump operating power is 400 to 450 kW/pump for a flow rate of 70 m3/hr
- There is good potential to optimize the pump power consumption by selecting of suitable large-capacity pump with head and flow

Recommendation

- Installed new energy efficient pump with the efficiency >75 %with optimized head & flow, (539 kW, 130 m3/hr, 1300 m)
- Energy saving potential: 200 kW

Sl.No	BFP	Unit	Old Pump (2 X 60 %)	New Pump
1	Flow (Q)	M3/hr	83.75	130
2	Head (m)	m	1725	1300
3	Power (kW)	kW	508	539
4	Efficiency (%)	%	63	75.8

4. HP Heater Replacement to Increase the Feed Water Temperature

Case Study:

- HP Heater outlet feed water temperature was less than 6 to 8 deg C the design temperature
- The reason for the temperature is due to the HP heater heating surface area
- Installed the new HPH with a higher heating surface area of 227m² against the old 127m² with approach <2.5 deg C & DCA <5 deg C. and with existing steam and feed water connection
- Plant achieved the reduction in the heat rate of 23 Kcal/kW of 27 MW Plant

5. Drip Transfer Pump Installation

Case Study:

- LP Heater drip temperature was around 110 deg C. Drip hot water was going to the air-cooled condenser duct and some portion of it was converted into steam and the rest water of 60 deg. Due to this flash steam is increasing the load on the condenser.
- A drip transfer pump was installed and drip hot water is being injected into a condensate pipeline at the outlet of the LP Heater.
- 15 kcal/kW is achieved on total plant heat rate and reduction on the condenser load and improved vacuum.

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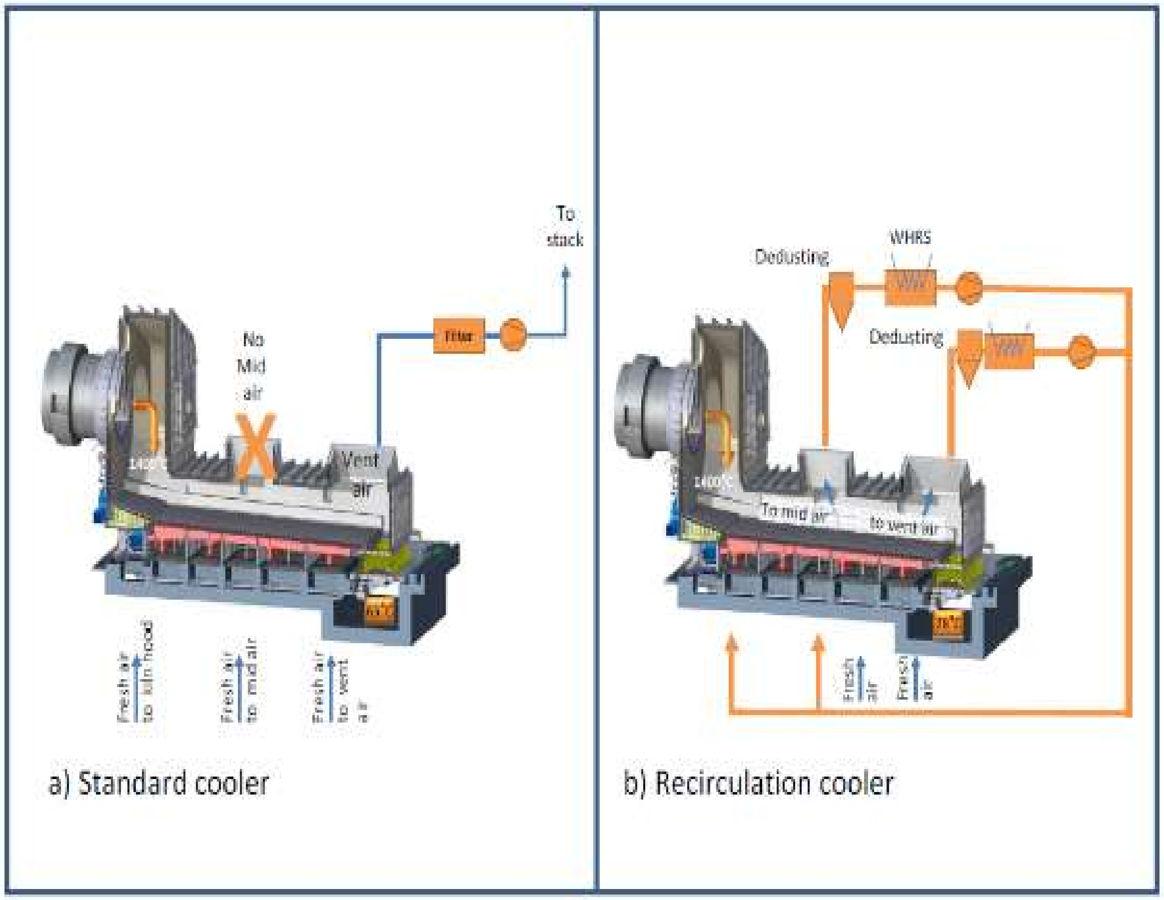
6. Cooler boiler exit gas recirculation for Enhancement in WHRB output

Cooler boiler exit gas recirculation for Enhancement in WHRB output

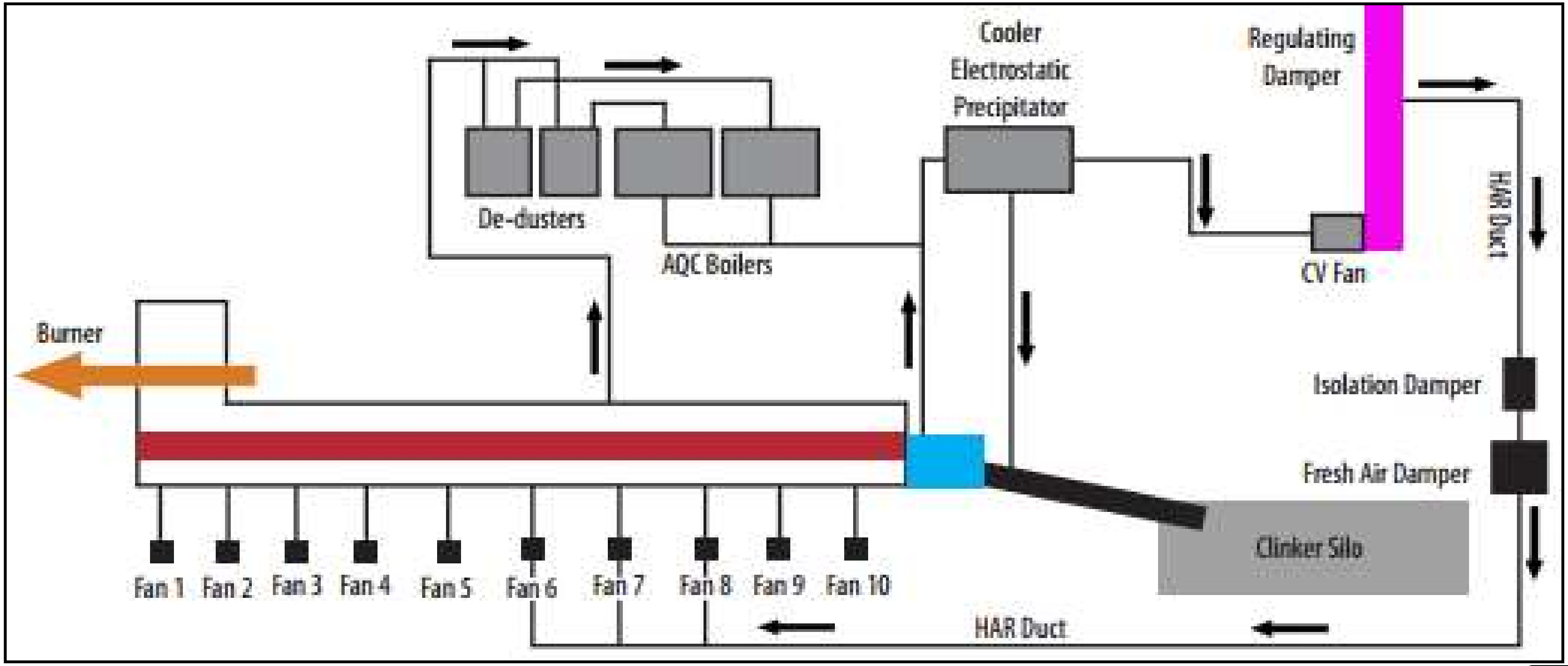


- ❑ **Conventional AQC Boiler arrangement**
  - ❑ **Hot gas input to boiler from mid air tapping and cooler vent air**
  - ❑ **Gas from boiler is vented to atmosphere at 110-130^{0}C**
    - ❑ **In some cases goes as high as 145 ^{0}C**

- ❑ **Hot air recirculation from cooler ESP vent stack**
  - ❑ **Part of hot vent air is recirculated back to middle fans**
  - ❑ **Increases temperature of mid air**
  - ❑ **Increase in generation from AQC side boiler**

Cooler boiler exit gas recirculation for Enhancement in WHRB output

Hot air recirculation from cooler vent stack to middle fans



Innovative Project

Installation of Hot Air Recirculation in Kiln-II to generate more green power

Duct From CV Stack

Entry At Fans

- Hot Air Recirculation in Fan Nos.6, 7 & 8
- Commissioned in January 2018
- Gross Power Generation Increased by 9,500 Units/Day
- Reduction in Green House gases 12,085 Kg CO_2/Day.

Cooler boiler exit gas recirculation for Enhancement in WHRB output

Benefits achieved from Hot Air Recirculation (HAR)- 5,000 TPD

Parameters	Unit	With HAR	Without HAR	Difference
Mid Air to Boiler	°C	410	390	20
HAR Temp	°C	130	30	100
Clinker Temperature	°C	144	124	20
Total Steam Generated	t/hr	27.23	24.72	2.51
Total Power Generated	MW	4.54	4.12	0.42
Total Power Generated	kWh/day	1,08,920	98,880	10,040

Particulars	Units/Day	
Increase in Power Generation from WHR System	kW	9,500
Reduction in Green House Gases	kg of CO_2	12,085

Cost Benefit Analysis

Total units generated : 31,35,000 kWh/Year

Total Savings : 17.24 Million/Annum (@5.5 Rs/kW)

Total Investment : 22.2 Million

Payback Period : 15 Months

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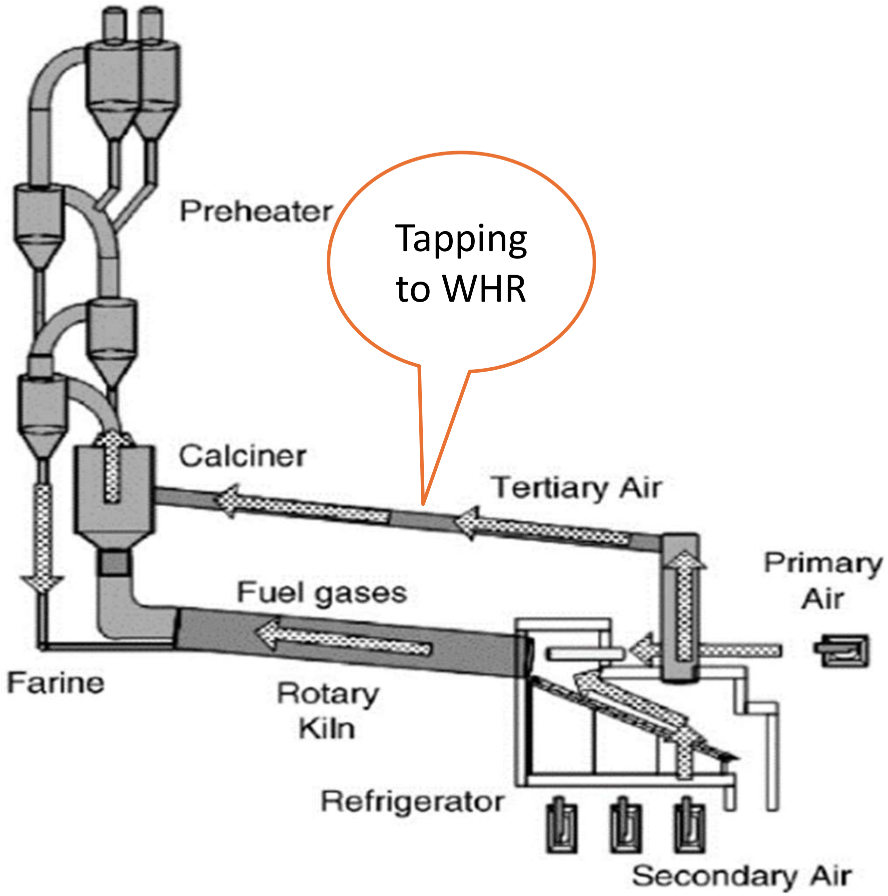
7. Tapping from tertiary air for enhancement in WHR output

Tapping from tertiary air for enhancement in WHR output

Tertiary air tapping

- Tapping from TAD duct
- Temp - 800 to 1,000°C
- Flow – 0.5 to 0.6 Nm^3/kg clinker
- Boiler exit temp – 450 to 500°C



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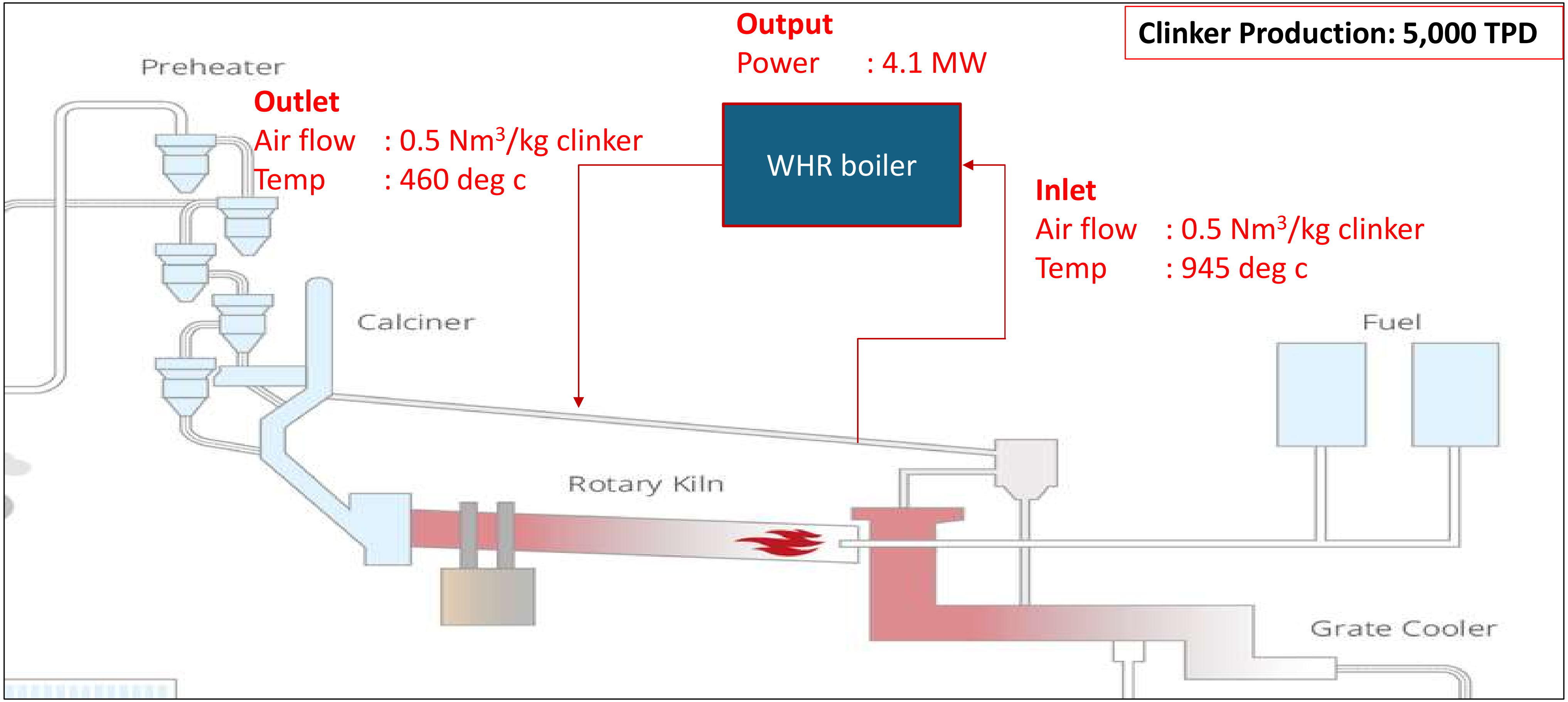
Tapping from tertiary air for enhancement in WHR output



Tapping from tertiary air for enhancement in WHR output

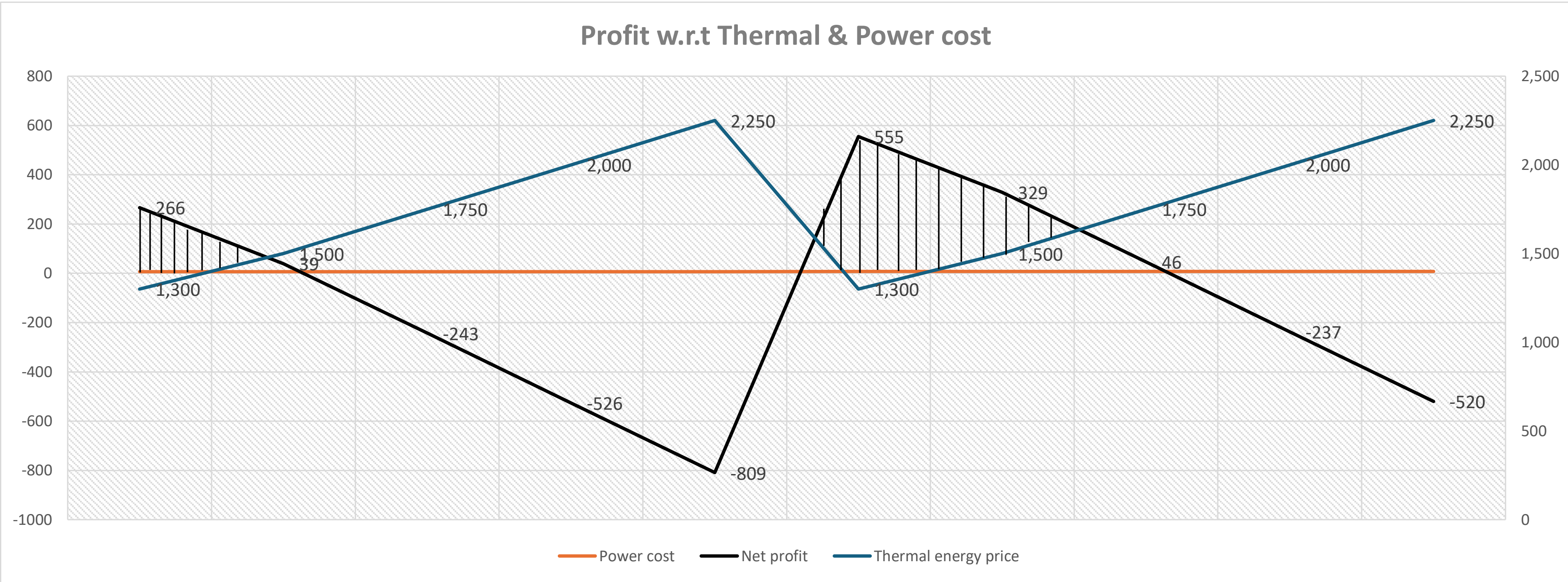
Impact of WHRB with Tertiary Air

	TAD	
TA temp WHRB inlet	Deg C	945
TA temp Calciner inlet	Deg C	460
TA flow	Nm3 / kg clinker	0.5
Clinker Production	TPD	5,000
Heat fed to WHRB	Kcal /hr	1,61,66,667
WHRB cycle efficiency	%	22
Power generated	**MW**	**4.1**
Increase in Sp. Heat consumption	kcal /kg clk	78

Thermal energy price	Rs /Mkcal	1,300	1,500	1,750	2,000	2,250	1,300	1,500	1,750	2,000	2,250
Power cost	Rs /kWh	6	6	6	6	6	7	7	7	7	7
Additional thermal energy	**Lakhs /annum**	**1,471**	**1,698**	**1,980**	**2,263**	**2,546**	**1,471**	**1,698**	**1,980**	**2,263**	**2,546**
Power cost saving	**Lakhs /annum**	**1,737**	**1,737**	**1,737**	**1,737**	**1,737**	**2,026**	**2,026**	**2,026**	**2,026**	**2,026**
Net profit*	**Lakhs /annum**	**266**	**39**	**-243**	**-526**	**-809**	**555**	**329**	**46**	**-237**	**-520**

Note: Benefit on tertiary air for power generation will vary with respect to thermal and grid electricity cost.

Tapping from tertiary air for enhancement in WHR output



|||||||| Profit zone

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THANK YOU !

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