AI–ENABLED PERFORMANCE ENHANCEMENT & ASSURANCE SERVICES

Leading Services Firm for the Global Cement Industry

Celebrating 57 years of Customer Satisfaction

HOLTEC

- Created in year 1967
- Services firm focused on the Global Cement Industry: Advisory, Engineering, Plant Operations & Maintenance, Solutions
- Also offer services in Highways, Power & Engineering Support Services
- 4,800+ assignments for 1,000+ clients in 100+ countries
- Full fledged engineering and business consulting firm
- Strong execution processes (ISO certified)
- Total Solutions: Integrated service from concept through commissioning and operations
- Industry expertise with 6,500 man-years experience
- Extensive database built over 55+ years
- Offices: 3 in India, 1 in UAE (Sharjah) and various other site offices

HOLTEC delivers comprehensive, end-to-end solutions tailored for the global cement industry

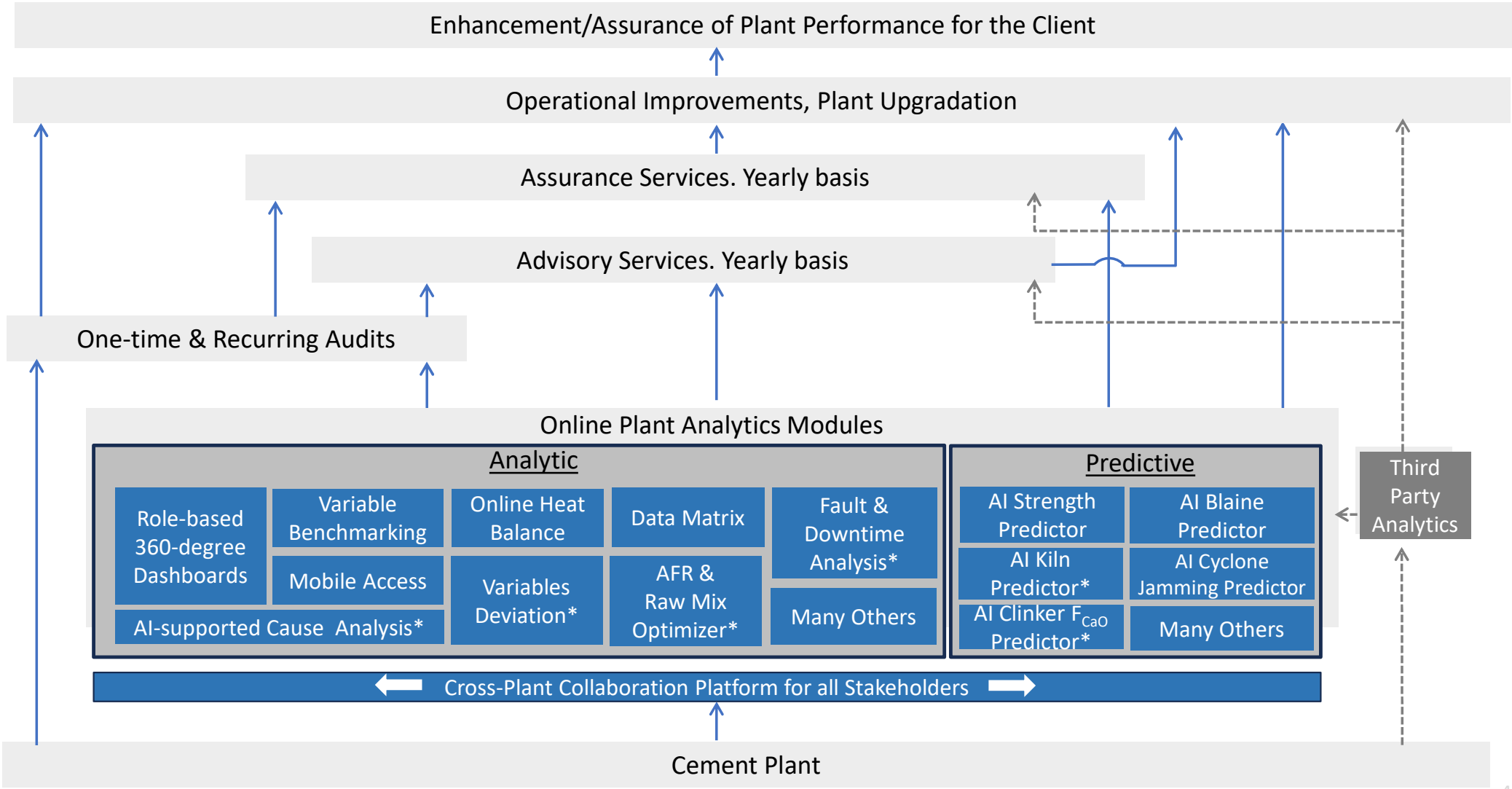
HOLTEC

EXPERIENCE IN THE GLOBAL CEMENT INDUSTRY

- 57 years of Service to 1000+ Clients Spread Over 100+ Countries
- 255+ New Cement Lines and Major Plant Upgradations
- 1,200+ Plant Modification Assignments
- 300+ Plant Audits & Performance Enhancement Assignments
- 4+ Online Plant Analytics & AI Solution Assignments
- 600+ Raw Material Investigation & Environment Assessment Assignments
- 140+ Captive Power Plant Assignments
- 70+ Waste Heat Recovery Plants
- 35+ Alternate Fuel Engagements

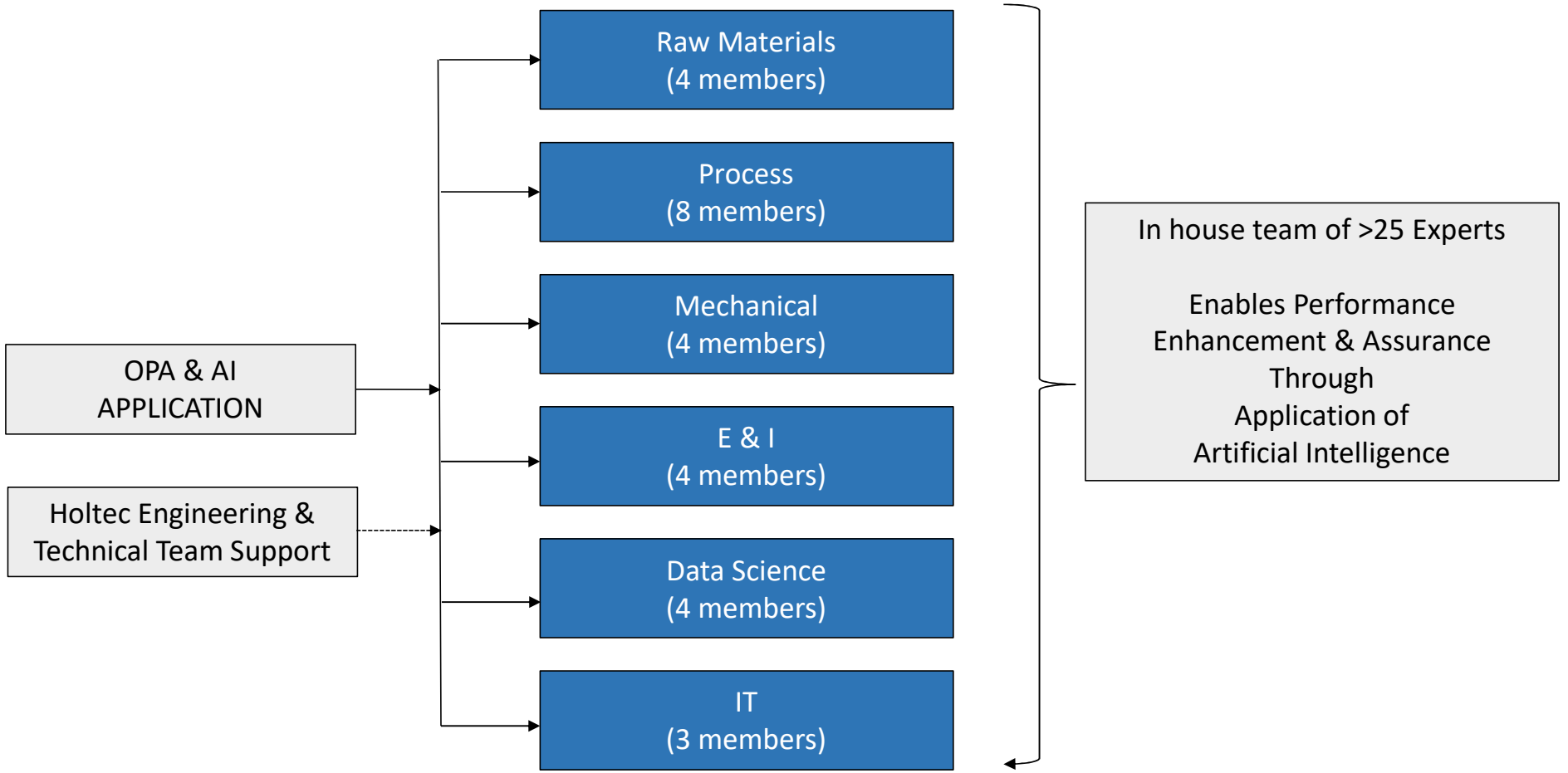
Our USPs, among others, include our Global Experience/ Access, Integration of our Multi-Disciplinary Expertise and Technological Contemporariness

AI–ENABLED PERFORMANCE ENHANCEMENT & ASSURANCE SERVICES



* Modules under development

PERFORMANCE ENHANCEMENT & ASSURANCE



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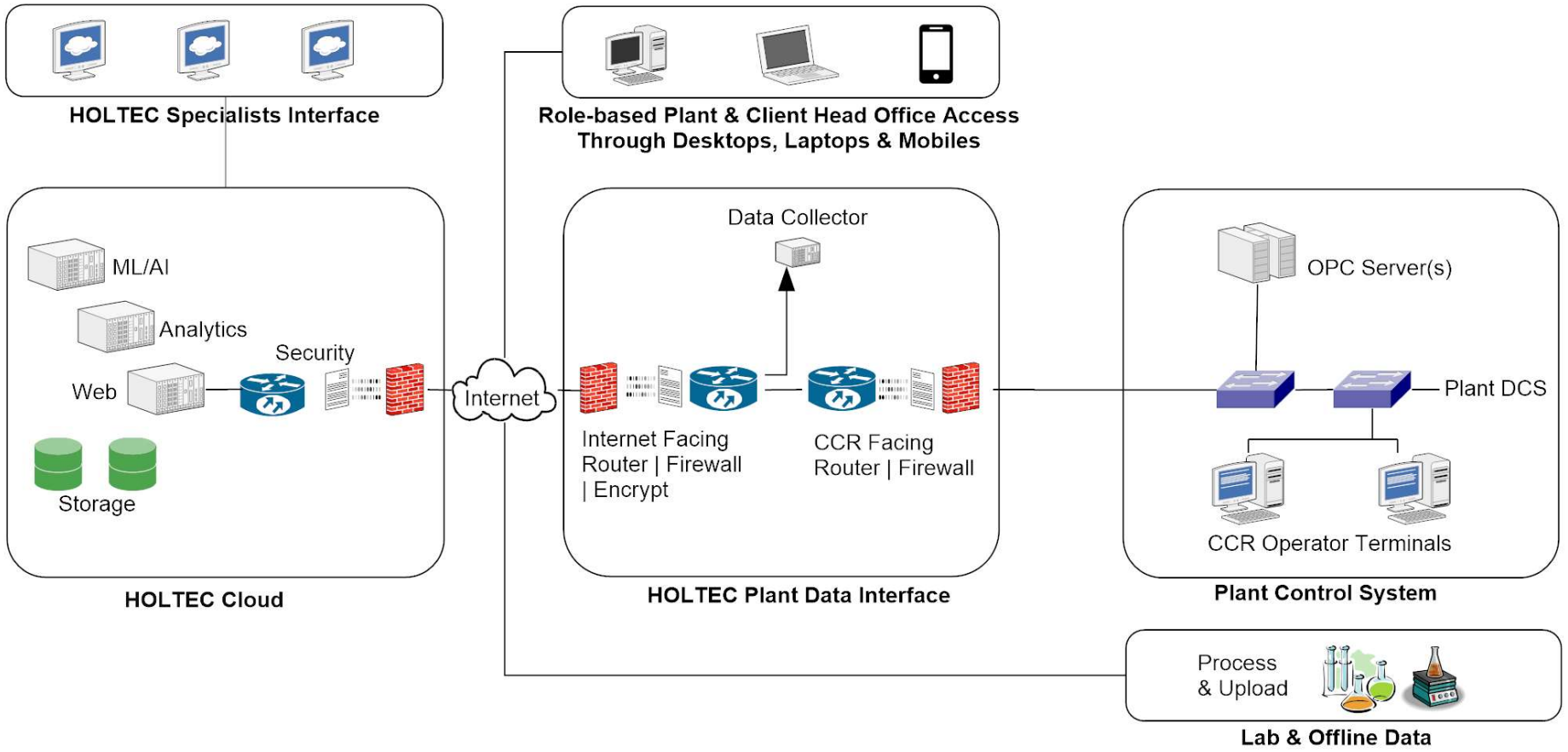
PHILOSOPHY : ONLINE PLANT ANALYTICS AND AI

Online Plant Analytics is a Service provided for Performance Enhancement & Assurance using Big-Data Analytics. This is being increasingly enabled through implementation of AI, by transforming Human Intelligence into computer algorithms, for its own learning & to deliver solutions, precisely.

The capturing, monitoring and analysis of Online Data is towards achieving optimized & stable operations on a long-term basis, regardless of changes in inputs and operating conditions (Men, Machines, Materials, Milieu, etc).

This is effected by continuously subjecting plant data to advanced analytics & AI-enabled systems to facilitate an Industry 4.0 approach towards conceiving and unleashing Performance Enhancement & Assurance.

SYSTEM ARCHITECTURE FOR OPA & AI IMPLEMENTATION



Number of Tags for a Typical Plant ~ (Total : 10,000)						
Tag Type	OPC	Lab & Offline	Alarm/ Faults (Virtual)	Calculated	Site Constants	Periodically Measured
~ Nos	1,500	100	8,000	220	100	80

IMPLEMENTATION APPROACH

Potential Assessment Study

- Preliminary assessment
- Collection of base line / past data
- Identifying improvement opportunities
- Identify areas that need regular monitoring for assured performance

Contract Finalization

- OPA Contract signing
- Agreement on improvement & assurance areas
- Agreed Terms & Conditions

OPA System Setup

- Online data capturing mechanism
- Data stabilization and mapping
- Formulation of AI/ML models & Optimization Tools

Performance Enhancement & Assurance Through Long Term Association

Holtec Intervention

- Activation of AI/ML based model/ tools
- Prescribing key variables/ Optimized range
- Recommending improvement measures

Sustainable Operation

- Supporting critical modification
- Periodic performance review
- Intermediate process study
- Experience sharing with Plant team
- Applying cost optimization models

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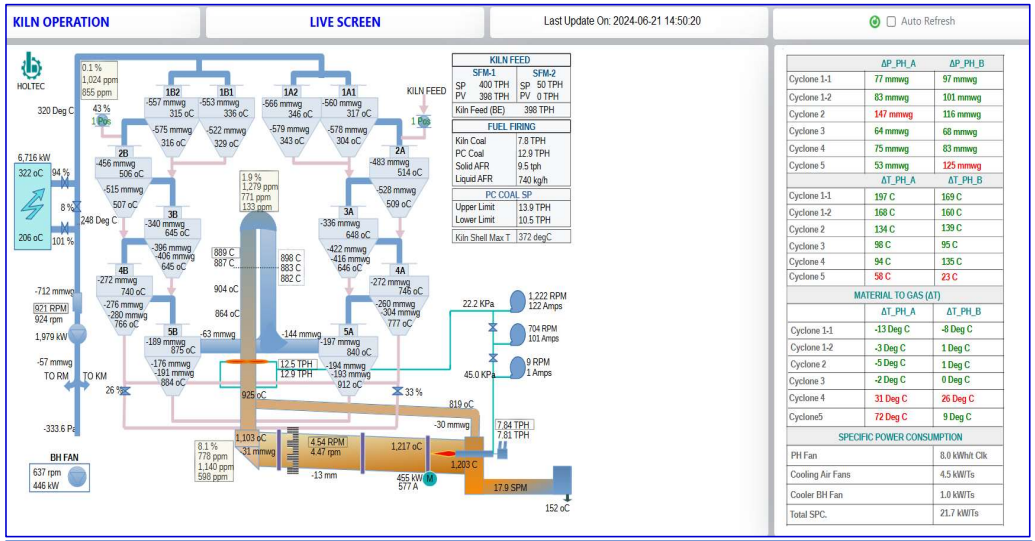
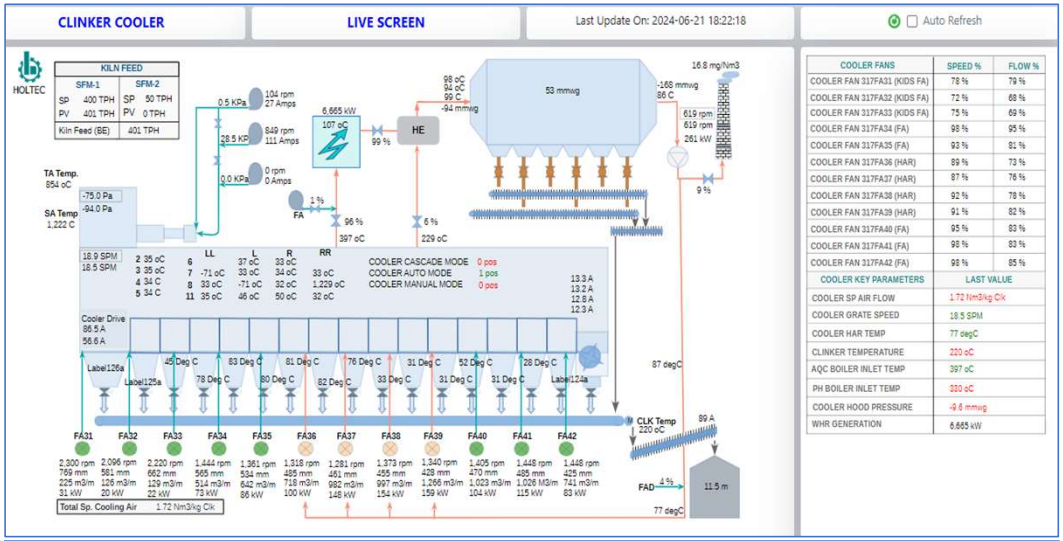
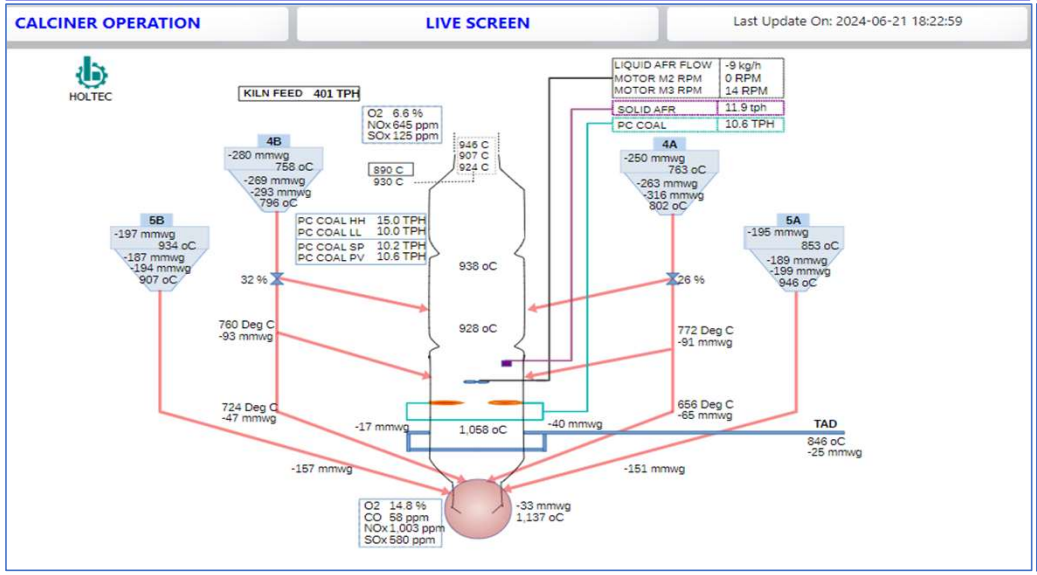
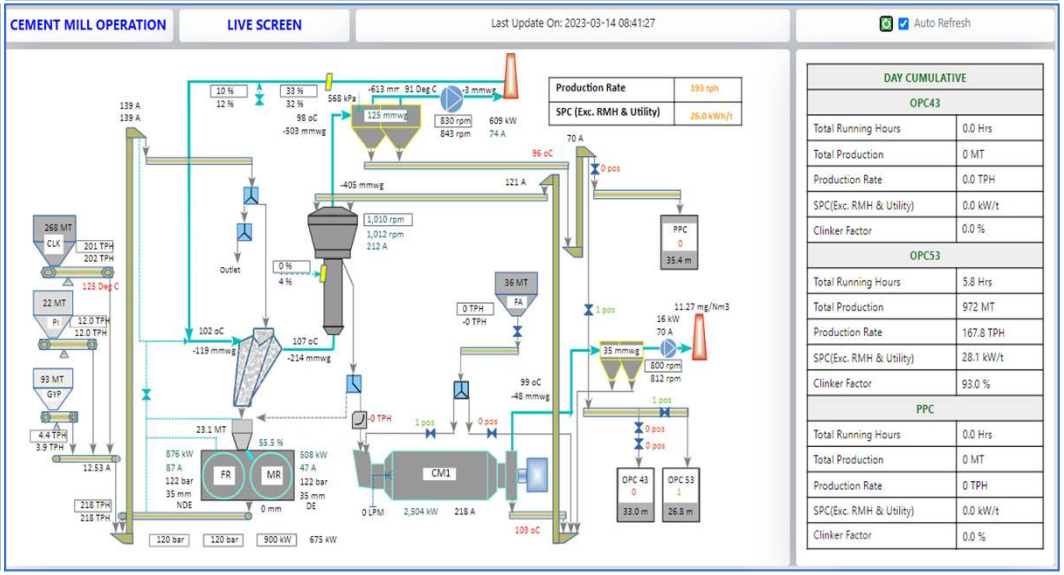
APPLICATION OF AI/ML FOR PERFORMANCE ENHANCEMENT & ASSURANCE

DIGITAL TWINS

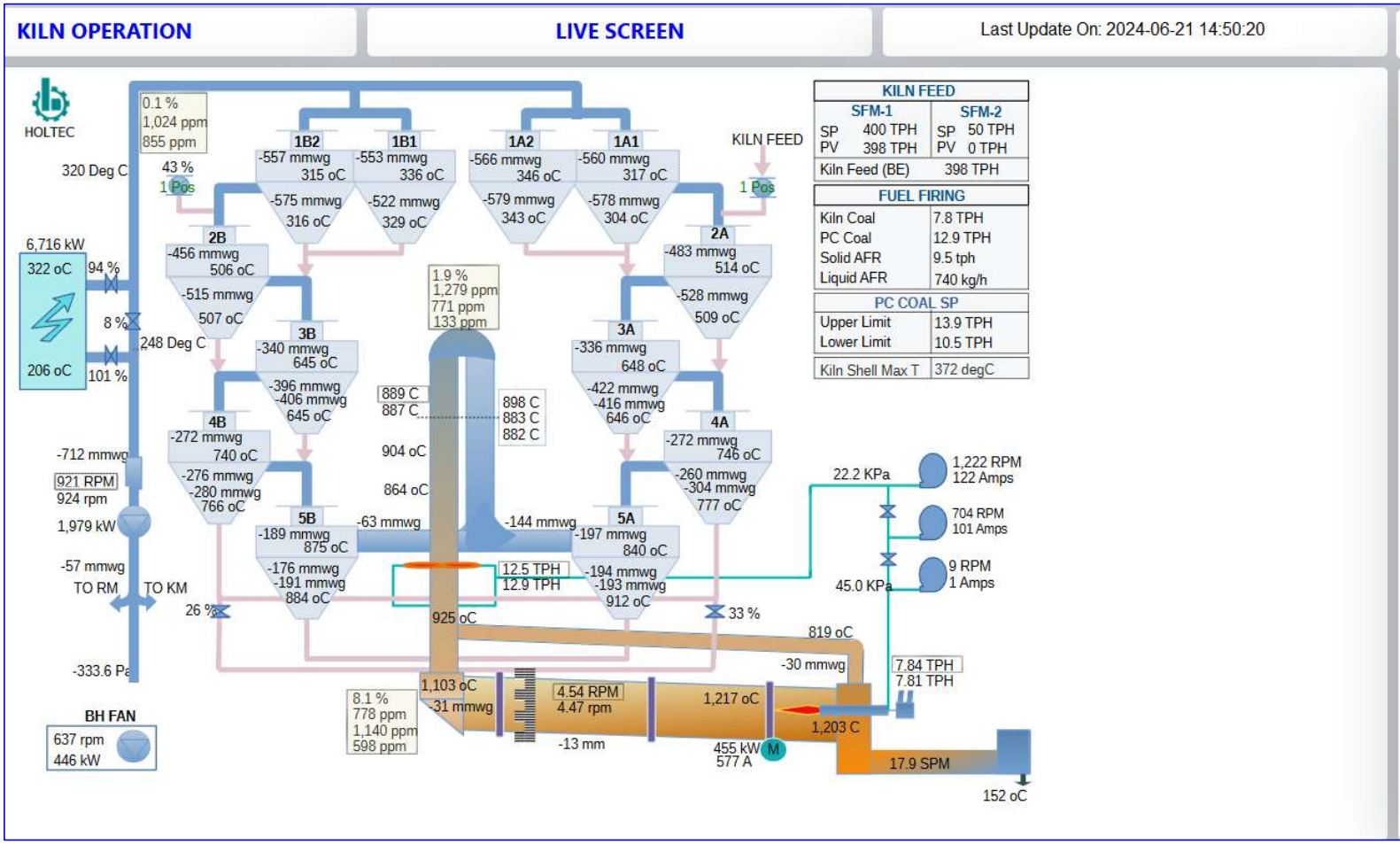








DIGITAL TWINS : PREHEATER & KILN



	ΔP_PH_A	ΔP_PH_B
Cyclone 1-1	77 mmwg	97 mmwg
Cyclone 1-2	83 mmwg	101 mmwg
Cyclone 2	147 mmwg	116 mmwg
Cyclone 3	64 mmwg	68 mmwg
Cyclone 4	75 mmwg	83 mmwg
Cyclone 5	53 mmwg	125 mmwg
	ΔT_PH_A	ΔT_PH_B
Cyclone 1-1	197 C	169 C
Cyclone 1-2	168 C	160 C
Cyclone 2	134 C	139 C
Cyclone 3	98 C	95 C
Cyclone 4	94 C	135 C
Cyclone 5	58 C	23 C
MATERIAL TO GAS (ΔT)		
	ΔT_PH_A	ΔT_PH_B
Cyclone 1-1	-13 Deg C	-8 Deg C
Cyclone 1-2	-3 Deg C	1 Deg C
Cyclone 2	-5 Deg C	1 Deg C
Cyclone 3	-2 Deg C	0 Deg C
Cyclone 4	31 Deg C	26 Deg C
Cyclone5	72 Deg C	9 Deg C

SPECIFIC POWER CONSUMPTION	
PH Fan	8.0 kWh/t Clk
Cooling Air Fans	4.5 kW/Ts
Cooler BH Fan	1.0 kW/Ts
Total SPC.	21.7 kW/Ts

ANALYTICS DASHBOARDS

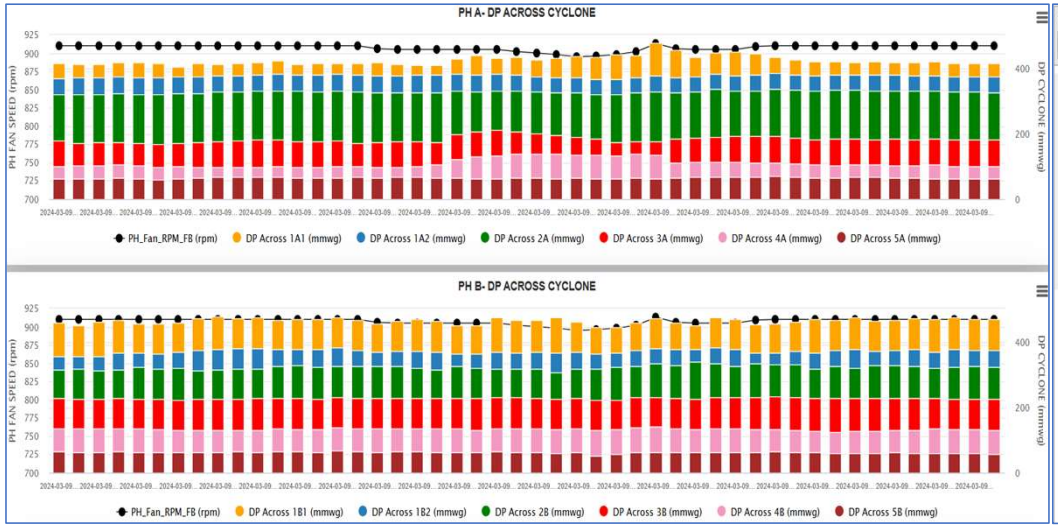
PROCESS VARIABLES ASSESSMENT | **HOURLY DATA** | Date: 2024-03-09 | Refresh

HOURLY AVERAGE

	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Optimized Range @ 6000 TPD
Kiln feed Total (TPH)	403	403	403	403	404	405	405	405	405	405	405	404	405	400	399	407	409	412	412	410	409	410	409	410	400-410 tph
Kiln Coal FB (TPH)	8.0	7.9	8.0	7.7	7.7	7.7	7.8	7.8	7.8	7.8	7.8	7.8	7.9	7.9	8.2	7.6	7.4	7.5	7.3	7.5	7.4	7.5	7.5	7.5	7.0-8.0 tph
PC_FCoal_FB (TPH)	11.8	11.5	11.4	11.7	11.9	12.0	12.3	12.6	11.6	11.5	11.8	13.9	14.5	13.7	13.7	11.3	12.3	12.5	11.6	11.8	11.8	11.7	11.7	11.6	11-14 tph
Solid AFR (tph)	8.2	9.5	9.7	9.5	9.0	9.0	6.5	7.6	9.5	9.4	8.4	4.2	0.0	0.0	1.2	9.7	9.3	8.1	9.8	9.8	9.8	9.9	9.7	9.8	8-12 tph
Liquid AFR (kg/h)	608	553	612	683	578	185	-121	-120	-121	-121	-31	-8	-9	-9	340	1,839	881	876	791	872	943	904	842	798	500 - 800 kg/hr
KL_RPM_FB (rpm)	4.52	4.54	4.54	4.54	4.54	4.57	4.59	4.59	4.59	4.59	4.59	4.59	4.59	4.50	4.56	4.64	4.64	4.64	4.64	4.64	4.64	4.64	4.63	4.64	4.50-4.70 rpm
KL_MD_Cur (A)	637	659	685	652	638	662	662	646	651	641	628	632	659	626	644	632	606	624	639	654	641	635	616	635	560-650 Amps
Kiln Inlet Temp (oC)	1,121	1,126	1,131	1,110	1,117	1,125	1,123	1,119	1,121	1,117	1,111	1,102	1,114	1,110	1,122	1,111	1,103	1,111	1,108	1,122	1,113	1,121	1,115	1,118	1110-1150 deg C
KL_SA_T (C)	1,225	1,220	1,221	1,226	1,218	1,210	1,197	1,199	1,212	1,169	1,173	1,178	1,192	1,175	1,185	1,220	1,213	1,201	1,209	1,225	1,216	1,222	1,226	1,208	1190-1250 deg C
BZ temp (oC)	1,326	1,285	1,301	1,292	1,318	1,322	1,289	1,284	1,284	1,285	1,260	1,259	1,252	1,227	1,291	1,288	1,264	1,266	1,266	1,298	1,282	1,298	1,305	1,287	1200-1350 deg C
PH_Fan_RPM_FB (rpm)	910	910	910	910	910	910	910	910	906	905	905	904	899	896	900	909	905	907	910	910	910	910	910	910	900-915 rpm
PH_OL_Temp (Deg C)	306	308	309	308	307	307	307	308	308	307	308	308	308	308	309	310	310	310	307	308	308	306	307	309	300-315 deg C
PC Outlet gas temp avg (C)	885	887	889	883	879	880	879	879	880	882	880	874	882	888	884	883	876	875	874	872	872	872	873	874	870-890 deg C
Tertiary Air Temp (oC)	982	975	971	996	968	953	936	934	947	958	953	922	937	947	916	980	969	946	966	960	970	968	984	964	920-990 deg C
CLR Mid Air Temp (oC)	372	371	370	396	386	362	366	363	362	382	392	368	366	386	369	390	393	380	387	372	386	375	379	376	360-390 deg C
Hood draft PV (Pa)	-70	-72	-69	-71	-69	-75	-71	-70	-70	-70	-71	-70	-71	-70	-77	-70	-71	-70	-70	-71	-76	-80	-80	-81	-60 to -75 pa
Sp. Cooling Air (Nm3/kg Clk)	1.72	1.69	1.71	1.60	1.64	1.67	1.65	1.67	1.67	1.66	1.63	1.66	1.67	1.62	1.69	1.66	1.65	1.64	1.62	1.68	1.64	1.65	1.65	1.62	1.63 - 1.70 nm3/kg clk
Cooler Grate SPM FB (SPM)	19.60	19.60	19.60	19.61	19.61	19.61	19.60	19.61	19.61	19.61	19.61	19.61	19.60	18.55	18.21	21.48	21.61	21.61	21.61	21.61	20.77	19.61	19.60	19.61	18 - 20 spm

Reasons for Variables deviation | Last Update On- 2024-03-09 14:26:38

VARIABLE	UNITS	OPTIMUM LIMIT	CURRENT VALUE	REMARKS
Kiln Feed	TPH	395	395.0	Normal Operation
Preheater outlet temperature	Deg C	310	315.0	high PC CO(1101.0)
SA Temperature	Deg C	1190	1,132.0	Cooler Kids Fans Flow (961.0) low
BZ Temperature	Deg C	1200	1,297.0	Normal Operation
TA Temperature	Deg C	920	965.0	Normal Operation
Midair Temperature	Deg C	375	365.0	Normal Operation
Clinker Temperature	Deg C	150	74.0	Normal Operation



ONLINE/ SITE ...	SECTION	DATE	OBSERVATIONS
Type Online or Site	Type Section	Type Date	Type Key Word
Online	Kiln	2024-03-09	Observations from 08 to 09 March: 1. The average kiln feed rate was 406 tph for both days, with the feed consistently running at over 400 tph for the majority of the time. 2. The Kiln Secondary Air temperature has shown improvement over the past few days, reaching above 1200°C. Additionally, the Kiln Burning zone temperature has also improved, with approximately 70-80% of the data falling within the optimized range. However, on the 8th of March, approximately 10% of the Burning Zone temperature data exceeded 1350°C, indicating a dangerous zone. It is imperative to maintain the Burning Zone temperature below 1350°C to ensure safe operation. 3. On the 8th of March, the Alternative Fuel (AF) firing remained quite consistent, with an average throughput of approximately 11 tones per hour (tph), using a ratio of 06 AW: 02 SW: 02 RDF (on a bucket basis). There was a reduction in AF ratios in the morning to maintain quality standards, as reported. For the 9th of March, the AF throughput averaged around 9 tph, and the system was stopped for 3-4 hours. In the morning, the AF ratio was 06 AW: 01 SW: 02 RDF, and it was adjusted after 12:00 hours to 06 AW: 02 SW: 03 RDF.
Online	Preheater	2024-03-09	Observations from 08 to 09 March: 1. The preheater (PH) exit temperature averaged around 307°C, while the PH fan speed maintained a range of 910-915 rpm. Remarkably, all observed data points fell within the optimum range, indicating an efficient operation of the plant. 2. The precalciner (PC) exit temperature PID setpoint (SP) was initially set at 880°C on the 8th of March. On the 9th of March, it was adjusted to 878°C and then further lowered to 872°C. These adjustments were made to ensure optimal calcination of the material within the precalciner, reflecting proactive measures to maintain the overall efficiency of the system. 3. The observed CO profile in the preheater exhibited a reduction, averaging around 700-800 ppm at the precalciner (PC) exit, cwith a preheater fan speed of 910-915 rpm. This improvement in CO levels may be attributed to adjustments in the Alternative Fuel (AF) mixing ratio and the quality of AF material used. The reduction in preheater fan speed has contributed to decreasing the preheater exit temperature. It is necessary to ensure consistency in the alternative fuel mix and quality to maintain minimum precalciner CO levels. This consistency will help sustain the improved CO profile in the preheater and optimize the overall efficiency of the system.

ANALYTICS DASHBOARD : KEY VARIABLES DEVIATION

PROCESS VARIABLES ASSESSMENT | **HOURLY DATA** | Date: 2024-03-09 | Refresh

HOURLY AVERAGE

	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Optimized Range @ 6000 TPD
Kiln feed Total (TPH)	403	403	403	403	404	405	405	405	405	405	405	404	405	400	399	407	409	412	412	410	409	410	409	410	400-410 tph
Kiln Coal FB (TPH)	8.0	7.9	8.0	7.7	7.7	7.7	7.8	7.8	7.8	7.8	7.8	7.8	7.9	7.9	8.2	7.6	7.4	7.5	7.3	7.5	7.4	7.5	7.5	7.5	7.0-8.0 tph
PC_FCoal_FB (TPH)	11.8	11.5	11.4	11.7	11.9	12.0	12.3	12.6	11.6	11.5	11.8	13.9	14.5	13.7	13.7	11.3	12.3	12.5	11.6	11.8	11.8	11.7	11.7	11.6	11-14 tph
Solid AFR (tph)	8.2	9.5	9.7	9.5	9.0	9.0	6.5	7.6	9.5	9.4	8.4	4.2	0.0	0.0	1.2	9.7	9.3	8.1	9.8	9.8	9.8	9.9	9.7	9.8	8-12 tph
Liquid AFR (kg/h)	608	553	612	683	578	185	-121	-120	-121	-121	-31	-8	-9	-9	340	1,839	881	876	791	872	943	904	842	798	500 - 800 kg/hr
KL_RPM_FB (rpm)	4.52	4.54	4.54	4.54	4.54	4.57	4.59	4.59	4.59	4.59	4.59	4.59	4.59	4.50	4.56	4.64	4.64	4.64	4.64	4.64	4.64	4.64	4.63	4.64	4.50-4.70 rpm
KL_MD_Cur (A)	637	659	685	652	638	662	662	646	651	641	628	632	659	626	644	632	606	624	639	654	641	635	616	635	560–650 Amps
Kiln Inlet Temp (oC)	1,121	1,126	1,131	1,110	1,117	1,125	1,123	1,119	1,121	1,117	1,111	1,102	1,114	1,110	1,122	1,111	1,103	1,111	1,108	1,122	1,113	1,121	1,115	1,118	1110-1150 deg C
KL_SA_T (C)	1,225	1,220	1,221	1,226	1,218	1,210	1,197	1,199	1,212	1,169	1,173	1,178	1,192	1,175	1,185	1,220	1,213	1,201	1,209	1,225	1,216	1,222	1,226	1,208	1190-1250 deg C
BZ temp (oC)	1,326	1,285	1,301	1,292	1,318	1,322	1,289	1,284	1,284	1,285	1,260	1,259	1,252	1,227	1,291	1,288	1,264	1,266	1,266	1,298	1,282	1,298	1,305	1,287	1200-1350 deg C
PH_Fan_RPM_FB (rpm)	910	910	910	910	910	910	910	910	906	905	905	904	899	896	900	909	905	907	910	910	910	910	910	910	900-915 rpm
PH_OL_Temp (Deg C)	306	308	309	308	307	307	307	308	308	307	308	308	308	308	309	310	310	310	307	308	308	306	307	309	300-315 deg C
PC Outlet gas temp avg (C)	885	887	889	883	879	880	879	879	880	882	880	874	882	888	884	883	876	875	874	872	872	872	873	874	870-890 deg C
Tertiary Air Temp (oC)	982	975	971	996	968	953	936	934	947	958	953	922	937	947	916	980	969	946	966	960	970	968	984	964	920-990 deg C
CLR Mid Air Temp (oC)	372	371	370	396	386	362	366	363	362	382	392	368	366	386	369	390	393	380	387	372	386	375	379	376	360-390 deg C
Hood draft PV (Pa)	-70	-72	-69	-71	-69	-75	-71	-70	-70	-70	-71	-70	-71	-70	-77	-70	-71	-70	-70	-71	-76	-80	-80	-81	-60 to -75 pa
Sp. Cooling Air (Nm3/kg Clk)	1.72	1.69	1.71	1.60	1.64	1.67	1.65	1.67	1.67	1.66	1.63	1.66	1.67	1.62	1.69	1.66	1.65	1.64	1.62	1.68	1.64	1.65	1.65	1.62	1.63 - 1.70 nm3/kg clk
Cooler Grate SPM FB (SPM)	19.60	19.60	19.60	19.61	19.61	19.61	19.60	19.61	19.61	19.61	19.61	19.61	19.60	18.55	18.21	21.48	21.61	21.61	21.61	21.61	20.77	19.61	19.60	19.61	18 - 20 spm

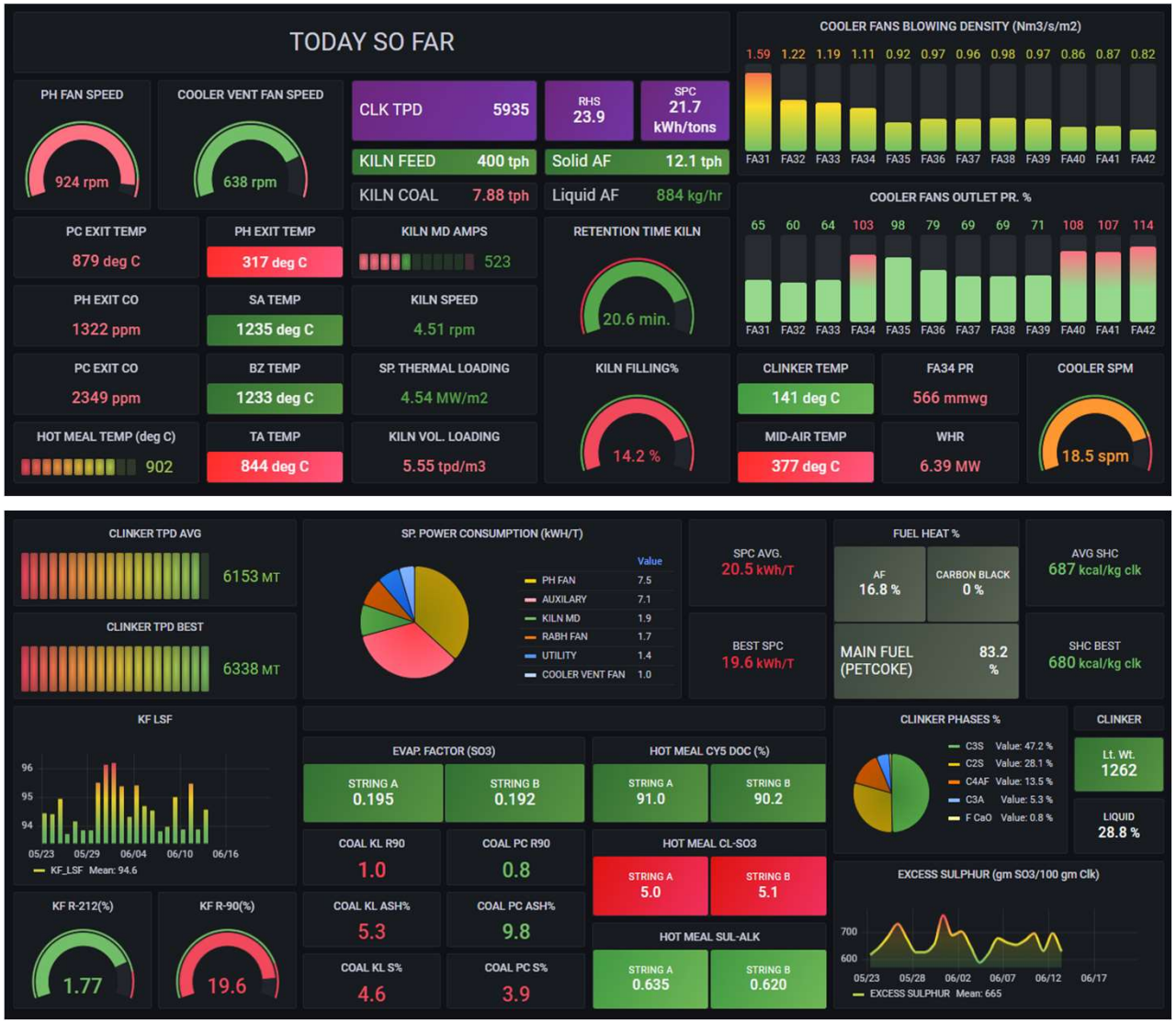
SMART MODULES

Performance Enhancement & Assurance Modules

Key Indicators	Unit Operations	Interventions	Collaboration	AI_ML Models	Data Analytics
Performance Indicators	Live Screen	Holtec Observations	Service Records	AFR & Raw Mix Optimization*	Data Matrix
Process Indicators	Graphical Correlations	Holtec Recommendations	Review Meetings	AI Kiln Predictor*	Real-Time Heat Balance
Quality Indicators	Brg. Temp / Vib. Monitoring		Plant Communications	AI Cyclone Jamming Predictor	Variables Deviation*
	Operations Review		Plant Reports	AI Blaine Predictor	AI Supported Cause Analysis*
				AI Strength Predictor	Fault & Downtime Analysis*
				AI Maintenance Predictor*	

* Modules under development

OPERATION DASHBOARDS



- **Role-based Dashboards**
  - Visible to Plant & Head office team from their offices, mobile devices, etc.
  - Can immediately share what issues they are seeing, with other team members, including in the CCR
- **Holtec team sees the same data**
  - Analyses it proactively
  - Shares recommendations with the Plant team

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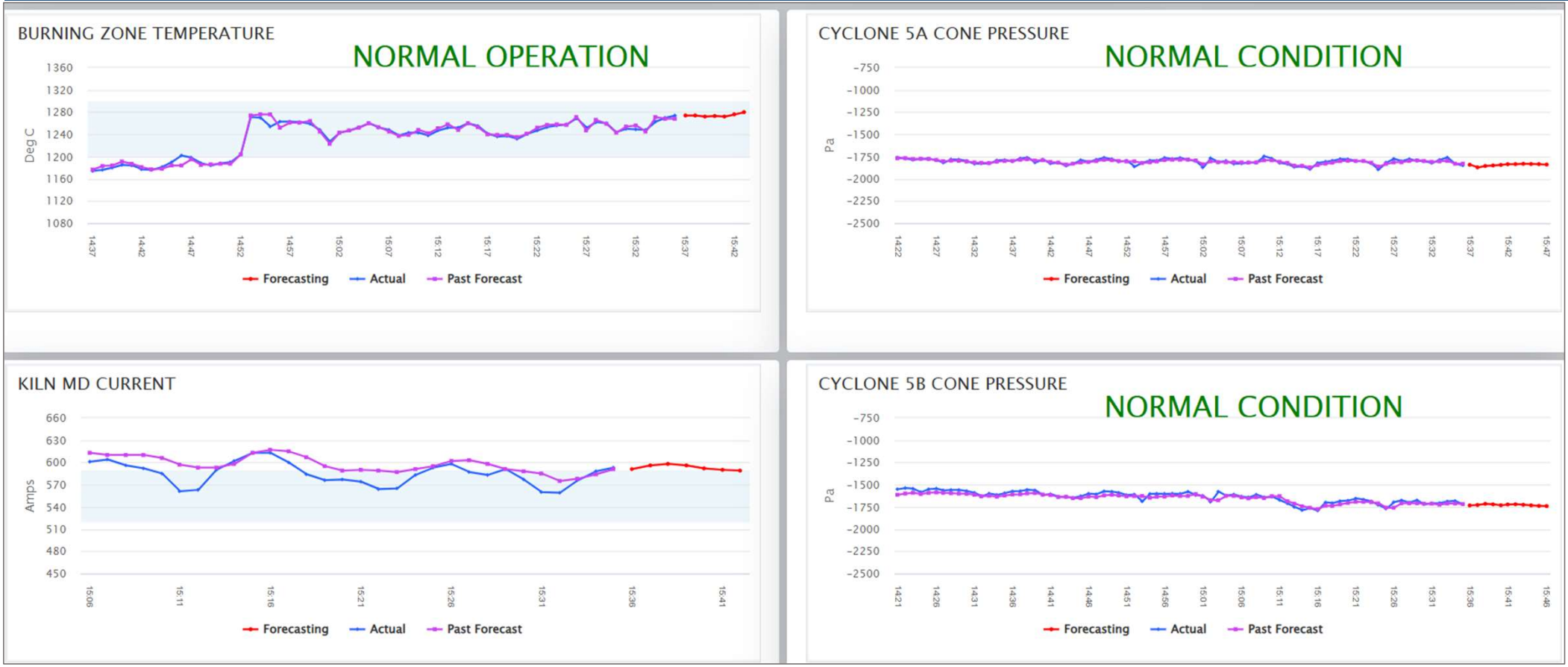
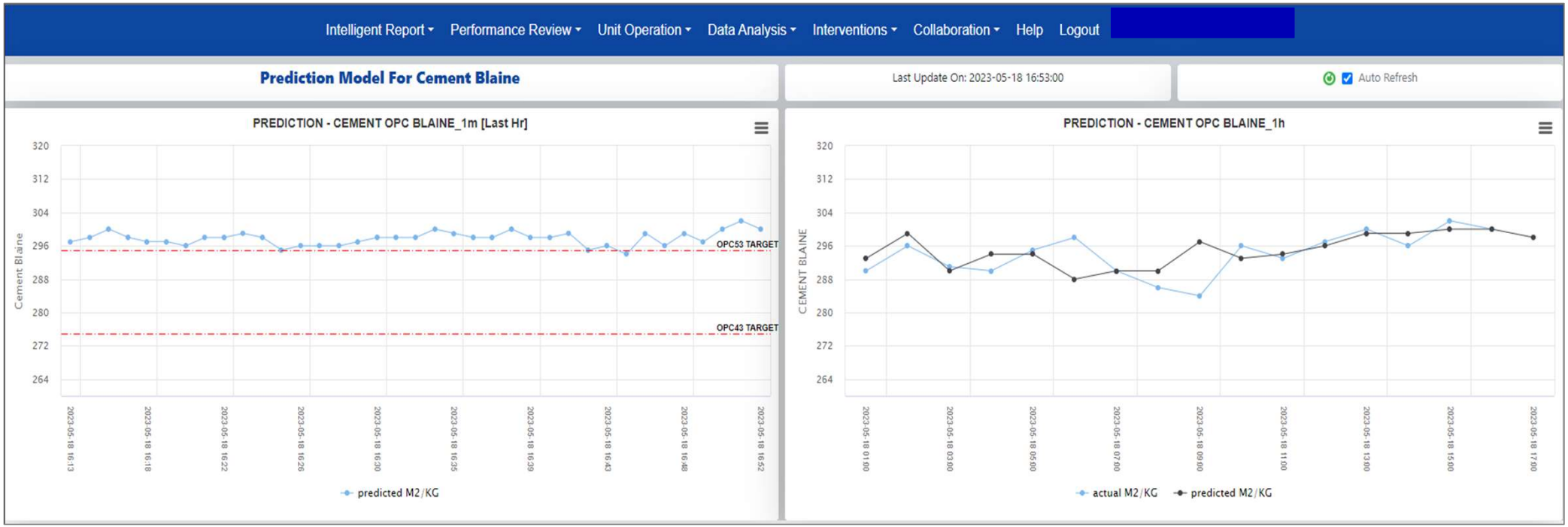
AI FORECASTING MODELS



Benefits

- Deep Learning Models for 'Kiln Operation' & 'Cyclone Jamming' forecasting in advance
- Preventing Kiln Down Condition can avoid Kiln Feed loss to the extent of ~1.6%
- Further, through early detection of Cyclone Jamming, chances of losing Production (~1.5%) can be avoided, for a single instance

AI BLAINE PREDICTION



Benefits

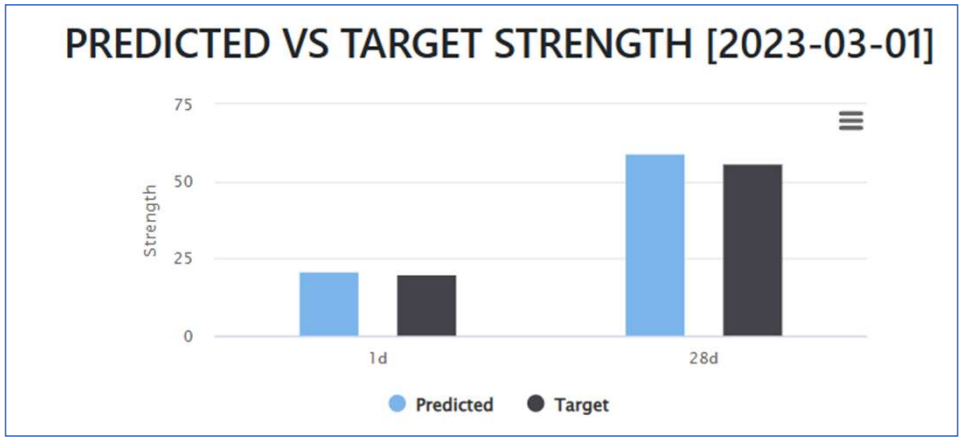
- Advance Prediction of Blaine and initiate proactive actions - to reduce variability in Operation & Quality
- ~1.5% improvement in Productivity and ~1.0% reduction in Sp. Power consumption is foreseen
- Learning the 'Best Operating Practice' from the data generated

AI CEMENT STRENGTH PREDICTION

	1 day Strength	28 Days Strength
Predicted Value	20.92	59.06
Target Value	20.00	56.00
Target Blaine	289.80	

Prescriptive Analytics for Target Blaine implicates desired Blaine target for the rest of the day

Prediction of 28 Day Strength



Benefits

- An early Prediction of Cement Strength (1D/28D) helps in identifying the quality of cement, in advance
- Reduces the probability of delivering Lower / Excess quality of cement, going into the market

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CASE STUDIES

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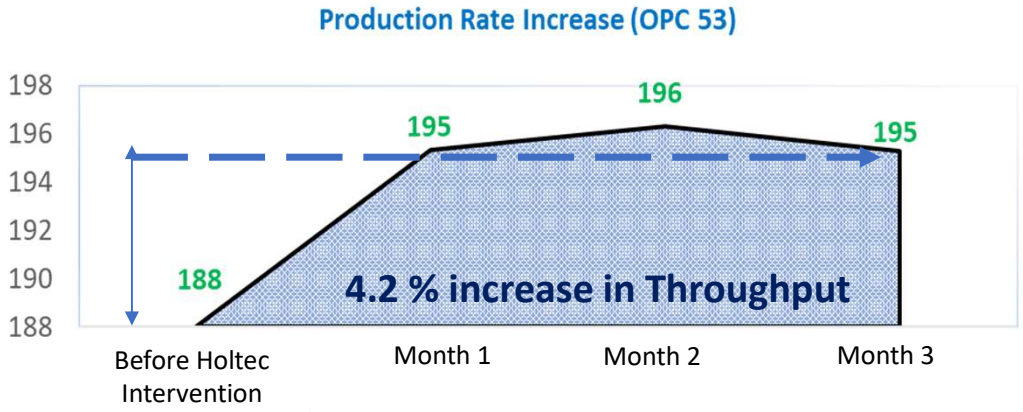
ACHIEVEMENTS : PLANT A (PPC GRINDING)

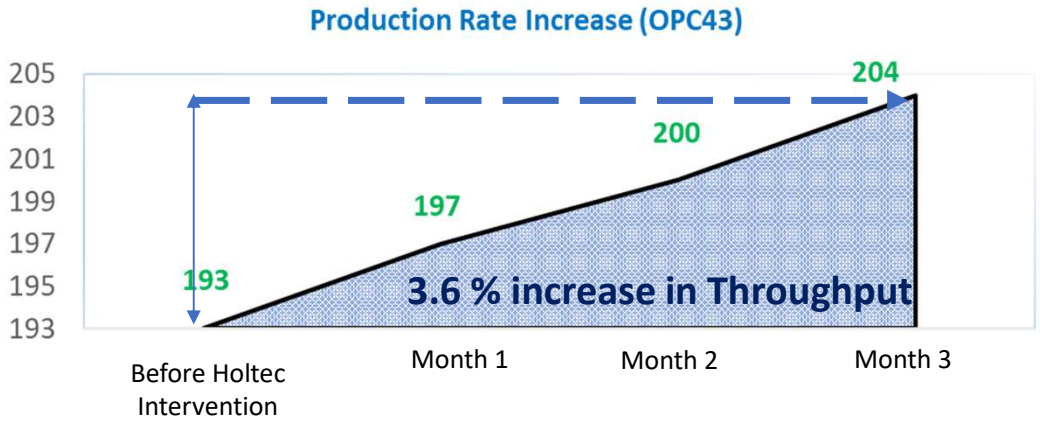
During the collaborative association, the benefits achieved over the period is mentioned as below:

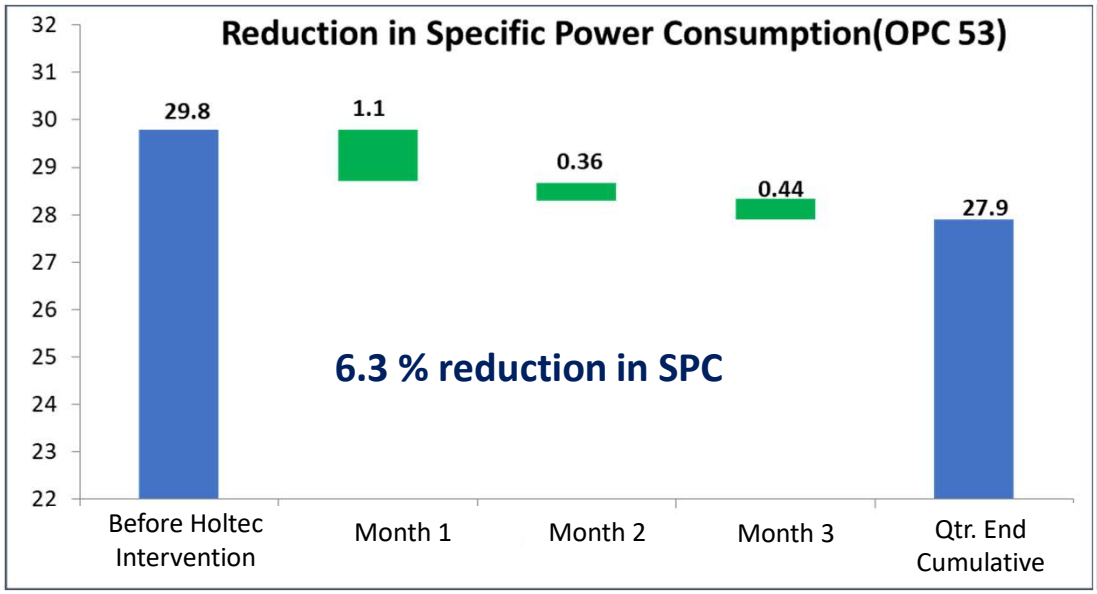
Parameters	Operating	Baseline	Achieved
Grinding SPC [kWh/t]	26.6	25.8 (3%) ⬇	24.2 (9%) ⬇
Clinker Factor	0.624	0.612 (2%) ⬇	0.615 (1.45%) ⬇
Throughput [tph]	243	253 (4%) ⬆	249 (2.5%) ⬆

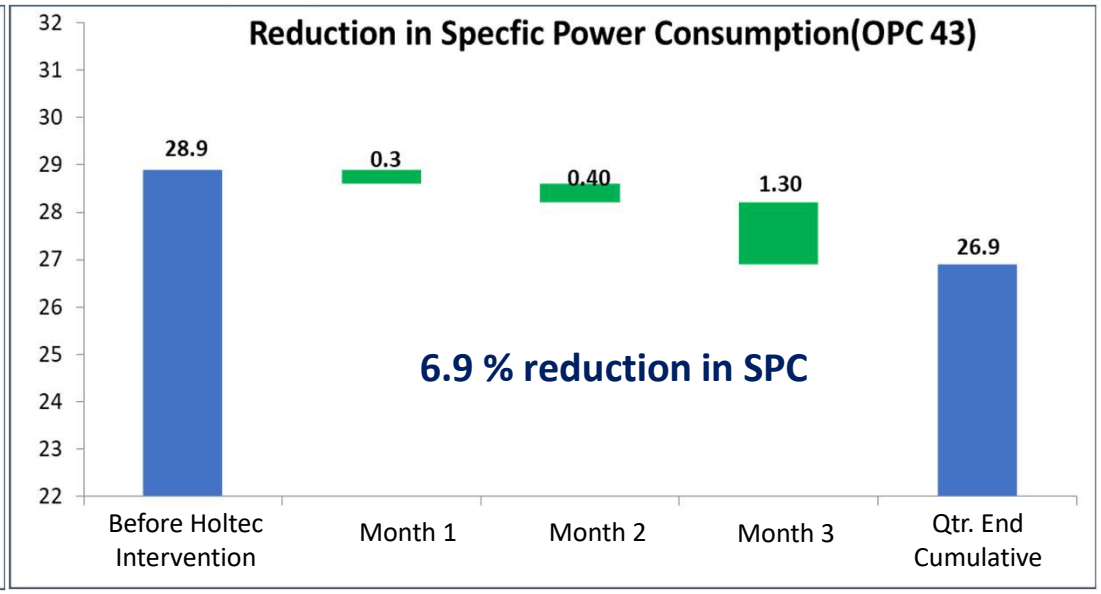
Reference Variables	Initial	Final
Fineness @ R45 [%]	7.5	7.1
Strength @1D [Mpa]	13.5	14.4

ACHIEVEMENTS : PLANT B (OPC GRINDING)









BENEFITS OF HOLTEC OPA AND AI SERVICES

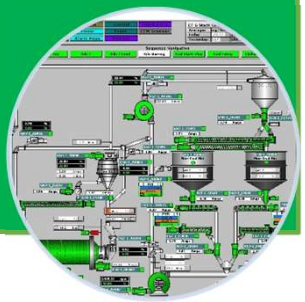
Operational Efficiency & Sustainability

- Process Stability
- Overall Energy Efficiency
- Consistency in Product Quality
- Cost optimization
- Exposure to technical developments
- Customized application

Improvements based on Deep-Data Analytics

- Improvement measures based on ‘Online Data’ evaluation
- Real time consulting solutions
- Risk free implementation
- Implementations, based on HOLTEC’s design, engineering & operational capabilities

HOLTEC Intervention



VALUE PROPOSITION THROUGH IMPLEMENTATION OF AI

Within Existing System Infrastructure

System KPI Improvement

System Throughput increase by 3-5%.....

Specific Power Consumption reduction by 4-6%.....

Specific Heat Consumption reduction by 1-2%.....

Clinker Factor reduction by 0.5-1.0%.....

AFR enhancement

Reduction in Carbon Footprints

Maintaining Sustainability

Prediction Models for Time-Lag Variables……

Forecasting Models for Key Impacting Variables……

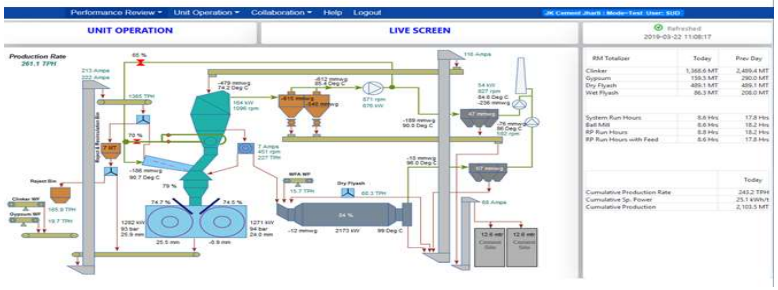
Wherever Capex/ Significant Modifications are Required, HOLTEC Engineering Team Can Work Closely with the Client Team to Design & Implement Optimal Solutions

CLIENT ACCESSIBLE ONLINE PLANT INFORMATION SYSTEM

Online Plant Analytics System is a mobile-enabled, secure platform that enables HOLTEC & it's OPA Customers to:

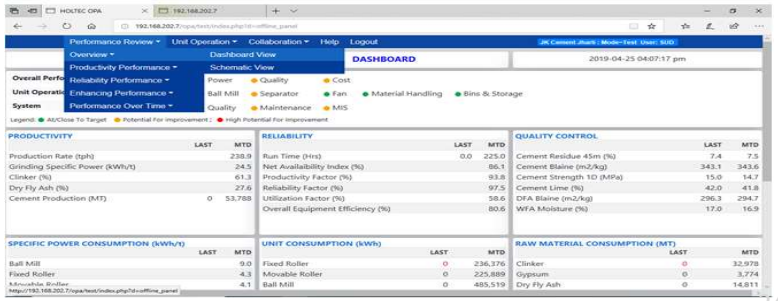
- **View running & historical Plant data** (from minutes to years), assess Plant KPIs using Trends & Charts
- **Monitor, analyse & correlate relevant variables** to keep track of complete plant operations
- **View all improvement interventions** made by HOLTEC & Client and the results thereof
- **Track communication** exchanged between HOLTEC & the Client during the process of engagement.
- Employ a host of other system features to facilitate operational transparency & enable improved performance-related decision making by Plant personnel

UNIT OPERATION: LIVE SCREEN



UNIT OPERATION: CURRENT OVERVIEW

PERFORMANCE REVIEW: OVERVIEW: DASHBOARD VIEW



APPLICATION OF AI/ML & ITS ADVANTAGE : PRESENT & FUTURE

- Various **AI based Prediction models** are being developed to address the Sustainability of key Operating Variables, which otherwise are not readily available like Cement Blaine, Cement Strength, Clinker Free lime, AFR maximization & Optimizing raw mix design, etc.

- Similarly, **AI based Forecasting models** address the expected changes in system parameters in advance, which otherwise may result into process disturbances, if not addressed on time. For e.g. Cyclone Jamming, Kiln and Cooler Operating Condition, etc.

- **AI/ML based Variable Deviation models** would help in identifying the Cause of Deviation on Real-Time and implementing corrective measures. For e.g. High PH Outlet Temp, Low SA Temp, Low BZ Temp, etc.

- **AI/ML based Optimization Tools** helps in Optimizing the Cost of Raw materials & Fuels, along with maximizing TSR and an advanced prediction of clinker quality, to ensure sustainable operation.

- **AI based Information Retrieval** mechanism to access Plant operation and maintenance guide, equipment manuals, etc., by using RAG and LLMs

HOLTEC's vision towards Plant Performance Enhancement includes implementation of the above AI/ML models, which are being developed based on specific improvement needs and are tailor made, based on plant specific conditions.

To achieve Sustainability in Operation and to reduce the Cost of Production, application of AI would certainly be at the center-stage in the coming time.

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