Council of Enviro Excellence

Date: 01 October 2024
Venue: Hyatt Centric, Janakpuri, New Delhi

FLEXIBLE OPERATIONS IN THERMAL POWER PLANT

Required Measures & Retrofits in Thermal Power Plants

Mr Archan Gor
Siemens Energy

Measures & Retrofits (Controls Measures): Flexible operations and Use cases from Indian Market

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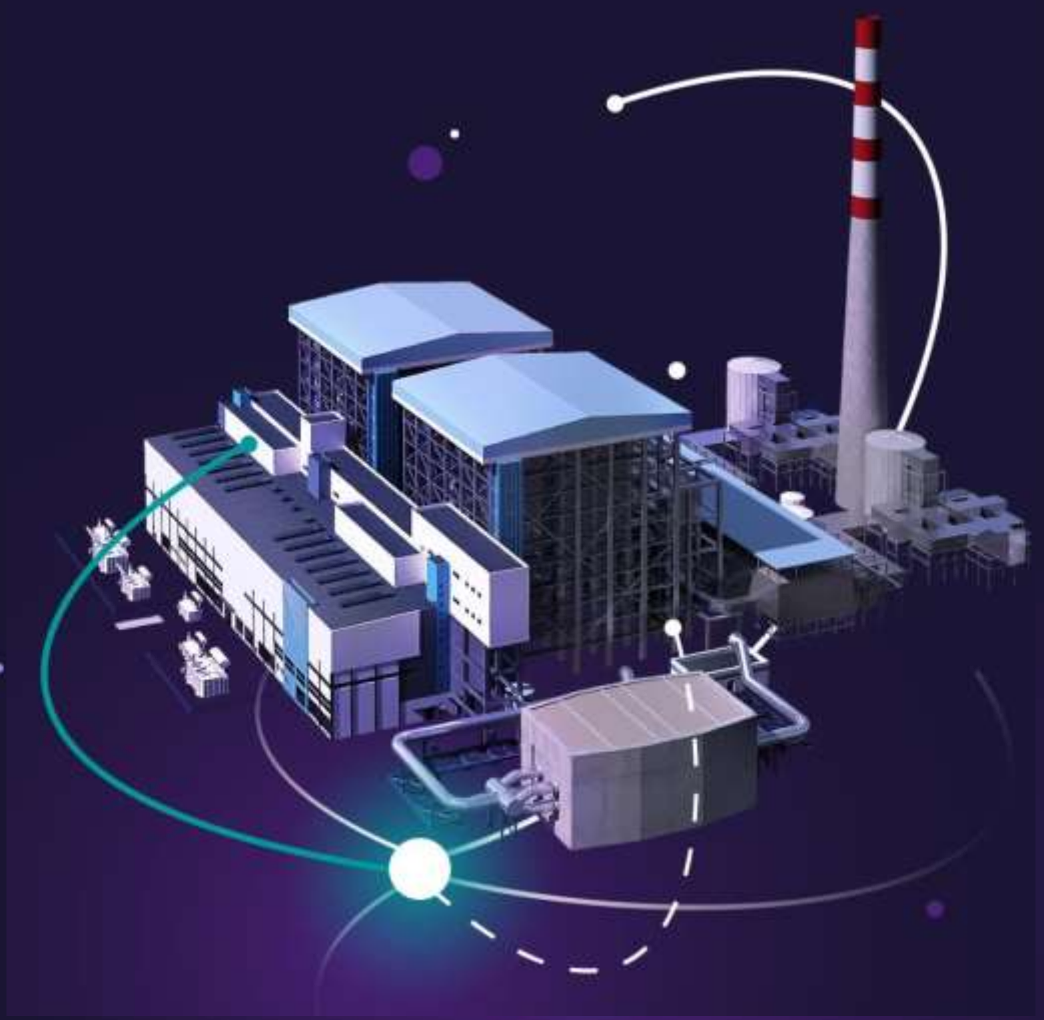


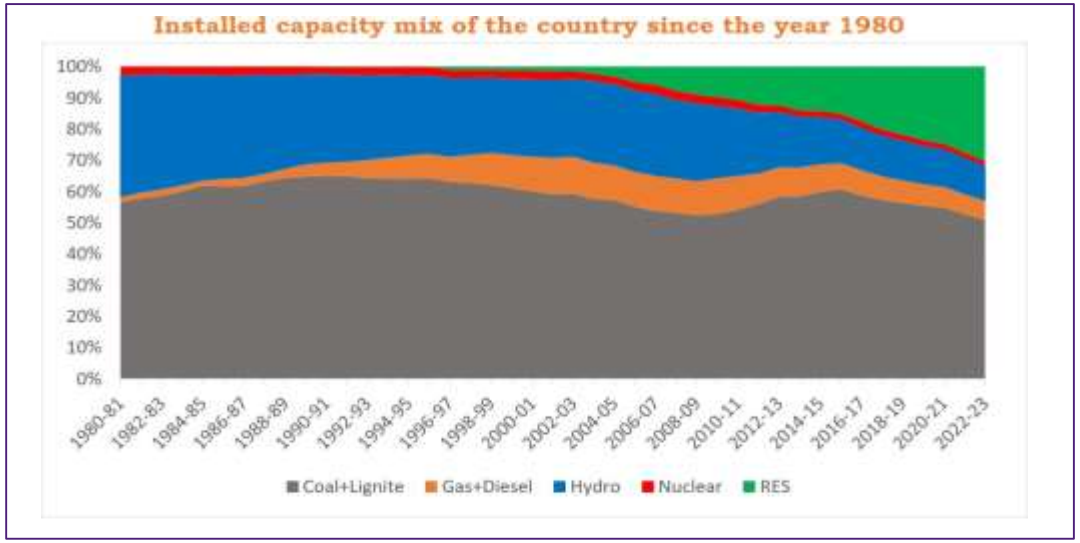
Omnivise
Performance Management Solutions

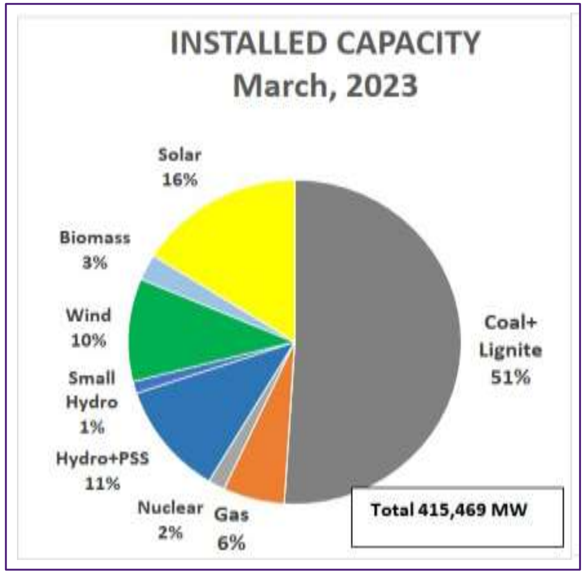
Flexible Operation

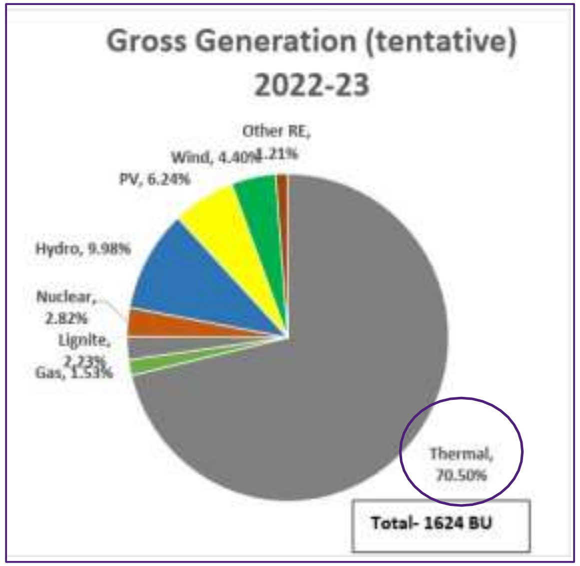
1st October 2024

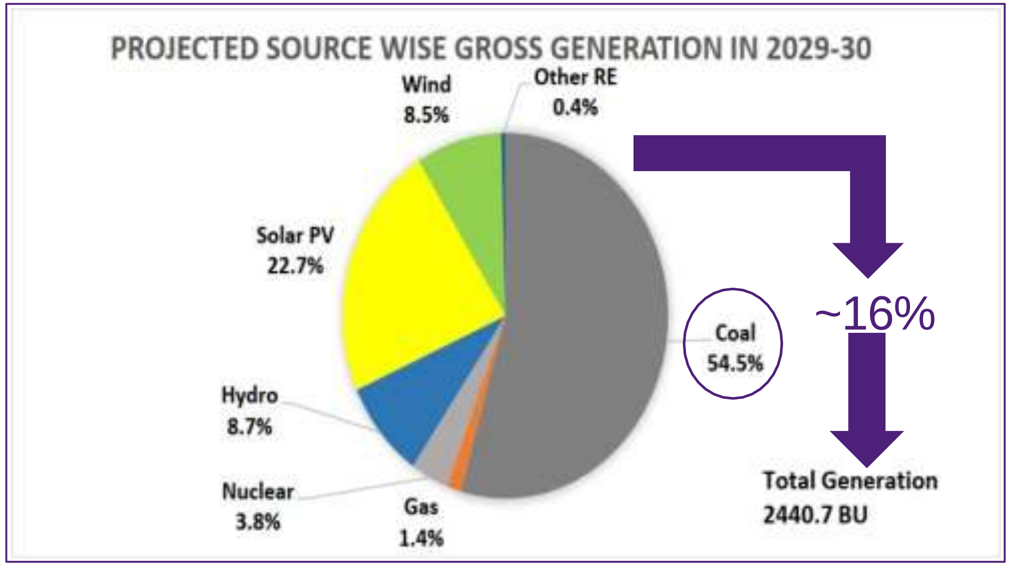
INDIA Power Mix

- The graph on the right illustrates a trend of generation in India’s since 1980.
- The graph illustrates a pronounced upward trend in renewable power sources, signaling a decisive shift towards cleaner energy solutions.
- With ongoing developments, the reliance on traditional fuels is evolving towards increased renewable energy utilization.



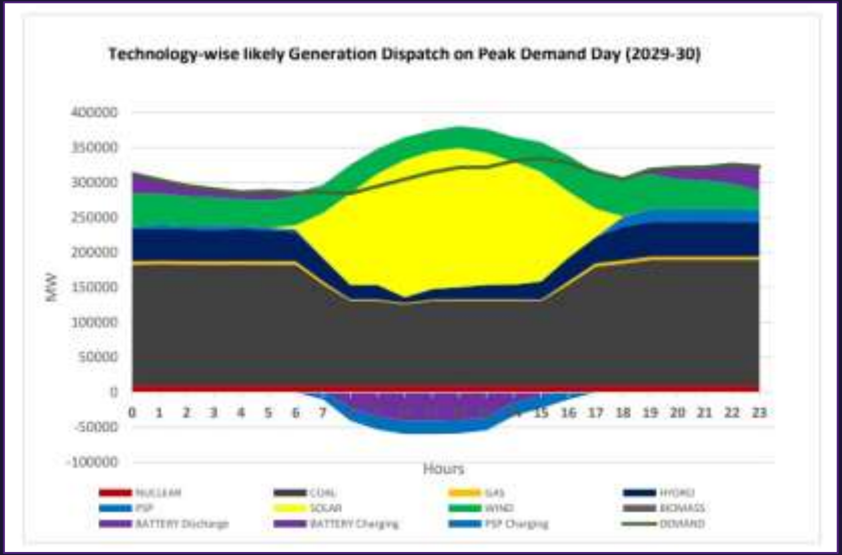


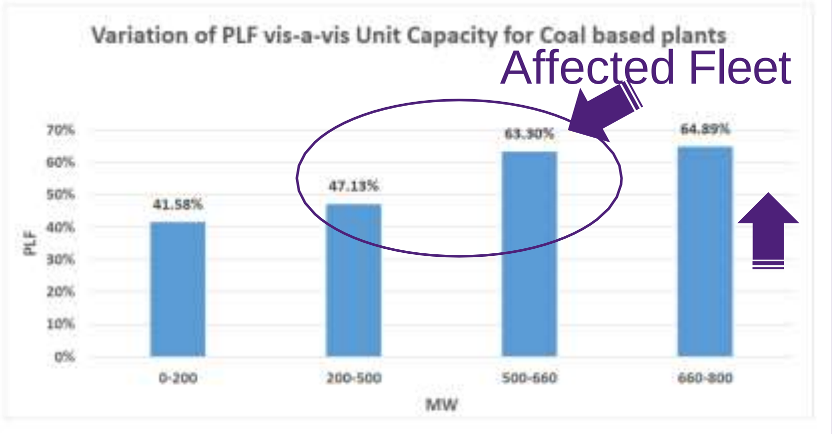




(Source: CEA’s report “REPORT ON OPTIMAL GENERATION CAPACITY MIX FOR 2029-30 Version 2.0”)

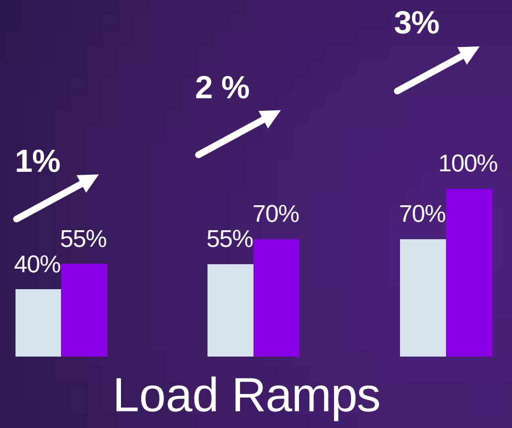
CEA Guidelines – Tackling the Renewable Integration





"Improved Control Systems"

Subsequently a draft phasing plan has been prepared for achieving 40% technical minimum load at coal based generating units. Different factors such as pit-head/ non-pithead, RE concentration, units having latest control system, CFBC technology, ball & tube mill, vintage units, cost etc. have been taken into account during preparation of phasing plan.



New Min Load – 40%
Ph I Starts July 2024
Ph IV Ends Dec 2030

(Source: CEA's report "REPORT ON OPTIMAL GENERATION CAPACITY MIX FOR 2029-30 Version 2.0")
(Source: CEA's notification on phasing plan dated 01 May 2023)

CEA Regulations Compendium – 20th August 2024
"Reliable, Efficient, and Sustainable electricity sector in India."

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Key Highlights of the CEA Regulations Compendium:

1. **Grid Standards:**
   Establishes a framework governing the operation and maintenance of the electricity grid, including standards for voltage, frequency, and system security, as well as the integration of diverse energy sources.
2. **Technical Standards for Grid Connectivity:**
   Sets technical requirements for connecting generating stations, including renewable energy sources, to the grid, ensuring stability and smooth integration of renewable energy.
3. **Safety and Electric Supply Measures:**
   Provides guidelines to ensure the safety of public, workers, and equipment during the generation, transmission, and distribution of electricity. It also includes additional safety requirements for electric vehicle charging stations.
4. **Safety Requirements for Construction, Operation, and Maintenance of Electrical Plants and Lines:**
   Establishes safety standards to prevent accidents and ensure the safe operation of electrical installations, including recent amendments mandating safety audits and the setup of early warning systems for hydro projects.
5. **Flexible Operation of Coal-Based Thermal Power Generating Units:**
   Ensures that coal-based power plants can operate flexibly, with a minimum power level of 40%, supporting the grid as the energy mix shifts towards renewable sources.
6. **Installation and Operation of Meters:**
   Standardizes metering practices to ensure accurate billing, enhance reliability, and promote transparency in the electricity sector.
7. **Furnishing of Statistics, Returns, and Information:**
   Mandates the submission of data related to electricity generation, transmission, and distribution to enable the CEA to monitor and analyze the power sector's performance.
8. **Technical Standards for Communication Systems in Power Sector:**
   Sets standards for communication systems, enhancing the operational efficiency of the power grid through improved data transfer and real-time monitoring.
9. **Technical Standards for Construction of Electrical Plants and Electric Lines:**
   Specifies standards for designing, constructing, and maintaining electrical plants and lines, ensuring safety, reliability, and efficiency.

(*Source: "PIB Delhi* - Union Minister Shri Manohar Lal Launches Compendium of CEA Regulations under the Electricity Act, 2003")

Challenges in achieving CEA guidelines
From SIEMENS Energy Aspects – Testing Experience

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210 MW and below	250 / 500 / 600 MW unit	660 MW and above
Combustion / Flame Issues	Metal Temperature Issues	Near to Benson Point Operation
Part Load Controls Issues	Drum Level Control and few other Control Loops	Intermittent water in separator tank vessel
Lower SH/RH steam temperatures at Part Load	Steam Temperatures Issues	Metal Temperature Issues
Fan Stalling		Single stream operation

Common Issues in all the units

Lower Flue Gas temperature at APH O/L

Low Ramp Rate

Impact on Thick Wall Components

Omnivise Performance Management

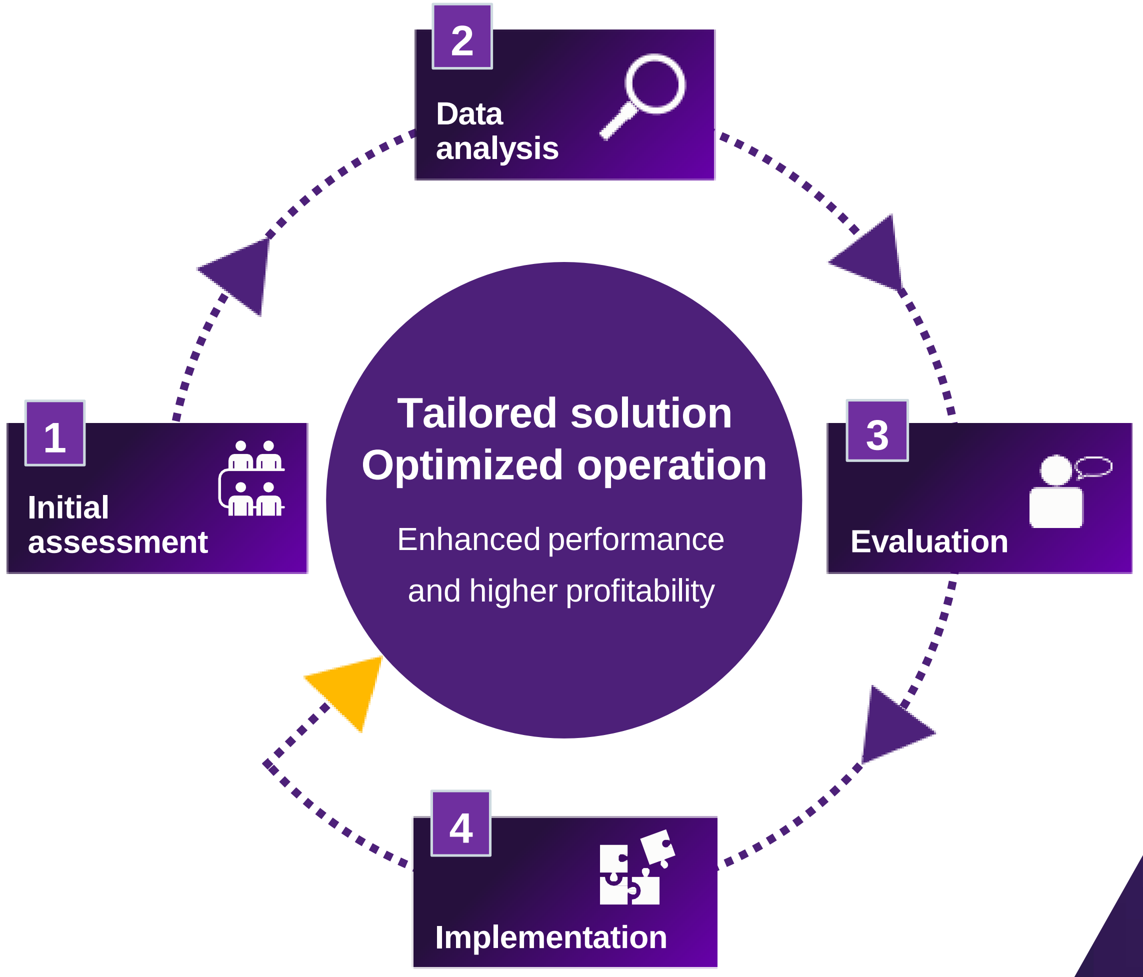
Operational Flexibility

Aging Plants and Controls

Emission Regulations

Cybersecurity Compliance

Concept Development of Optimization Project



1. Siemens Energy team created a plan to modernize the coal plant through upgrading only the control system with Plant Optimizer solutions.
2. A site survey was done to identify and quantify potential by analyzing operational data
3. Presentation of expected results including estimates of potential return on investment (RoI) was done.
4. Engineering and commissioning to be done based on comprehensive power plant know-how and optimizers Implementation for Project (6 – 8 months implementation Cycle)

Control solutions to address the challenges

Challenges	Solutions	Benefits
Low Ramp Rate Combustion / Flame issues Steam & Metal Temperatures	Enhanced unit master controls Combustion Optimization & Controls Temperature Optimizer	Higher Ramps Lesser Operator Intervention Better Reliability
Auxiliary Power	Auto Cut In/Off Auxiliaries Mill Scheduler	Reduced Aux. Power Lesser Operator Intervention Better Efficiency
Impact on components Lower Flue gas temperature at APH O/L	Fatigue Monitoring System Combustion Tuning & Optimization along with Soot blowing Optimizers	Low stress operations Shutdown planning

Topics for Must-Needed Discussion

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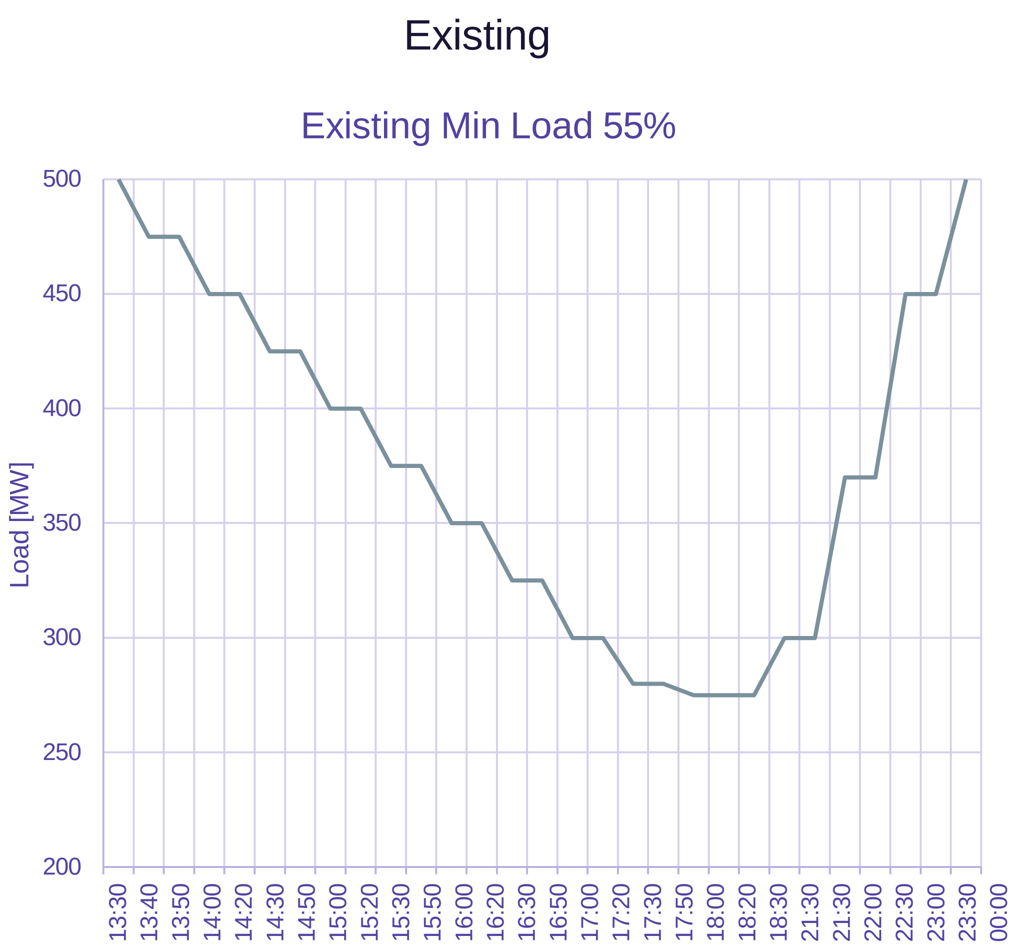
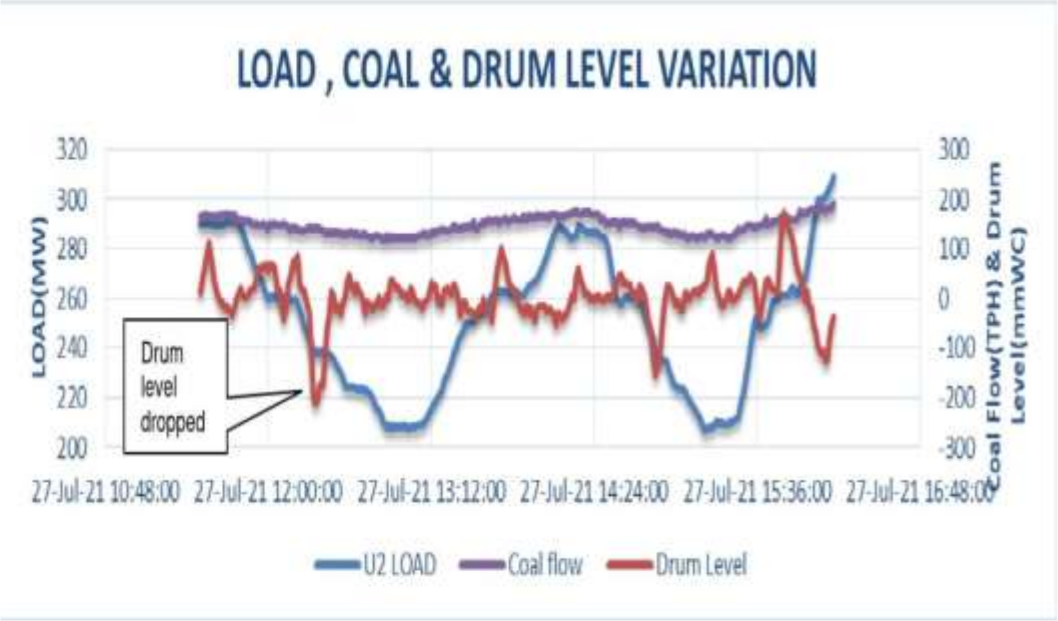
Minimum Load Reduction

Ramp Rate

Reliability through Monitoring
Fatigue Monitoring System

Minimum Load - What is existing in Plant !

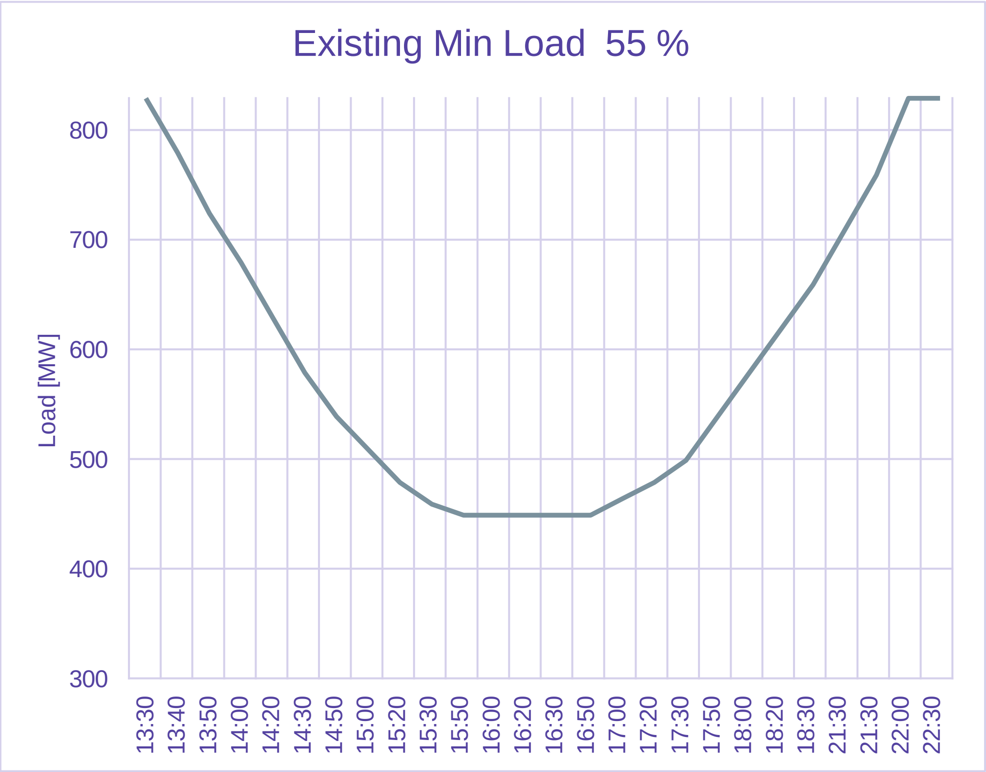


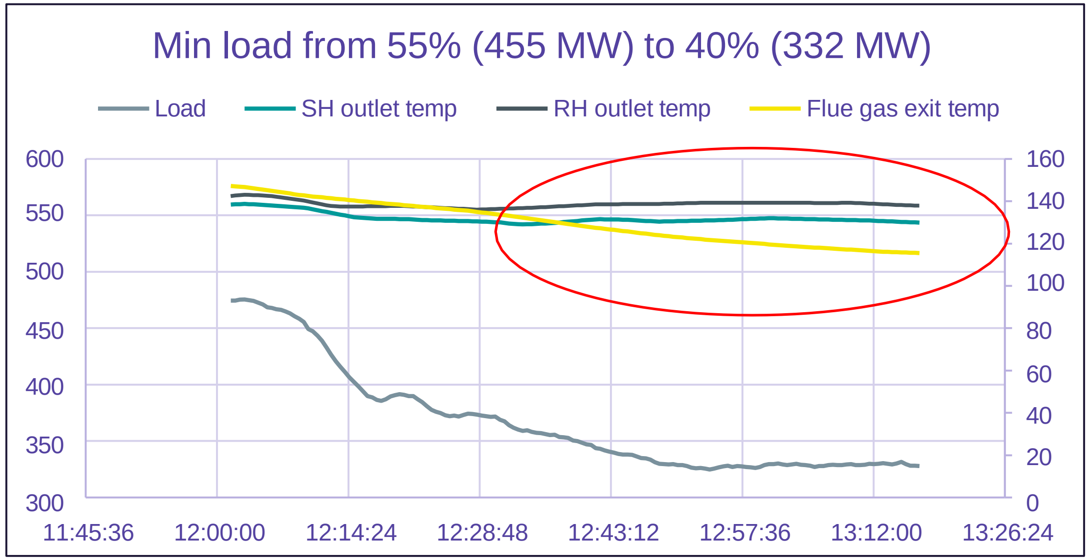


When tried to flex and reached minimum load

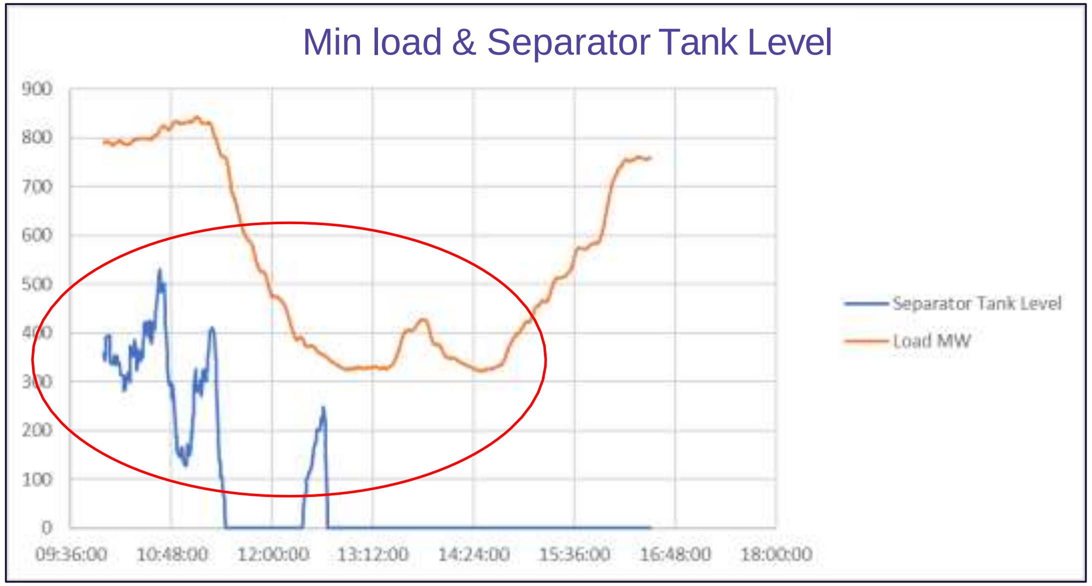
Minimum Load - What is existing in Plant !

Existing





When tried to flex and reached minimum load



Minimum Load Reduction

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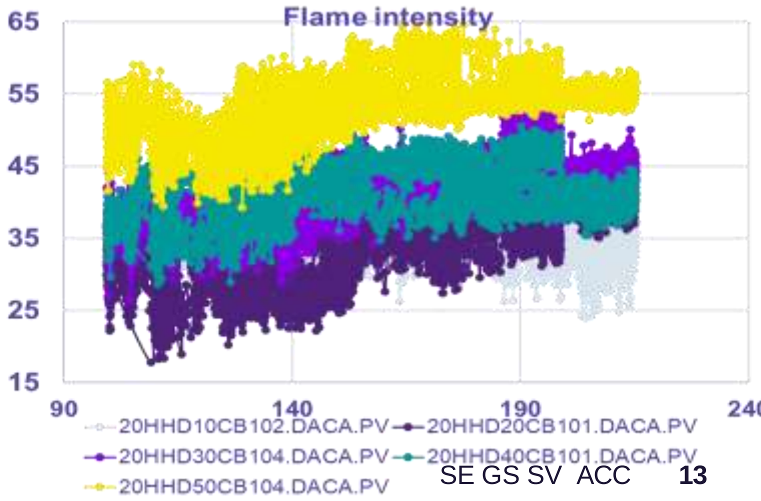
Plant Issues	Field Findings
Plant – 1 Flame Stability	Further loop tuning and combustion controls optimization required
Plant – 2 Benson Point	Loop controls & modified pressure curves, Evaporator Extended Studies (Thermohydraulic Studies)
Plant – 3 Metal Temperatures Plant – 3 Water in Separator Tank	Basic control loops tuning and need for unit controller for optimizing the loops are required
Plant – 4 APH O/L Temperature Low	Combustion control optimization and Soot blowing optimizers



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Minimum Load Reduction

Reduced minimum load level through improved automation

Est. Lead Time
6 Months

Min. Event Type
Minor

Fleet Experience
>10 Units

Power
- Power Savings

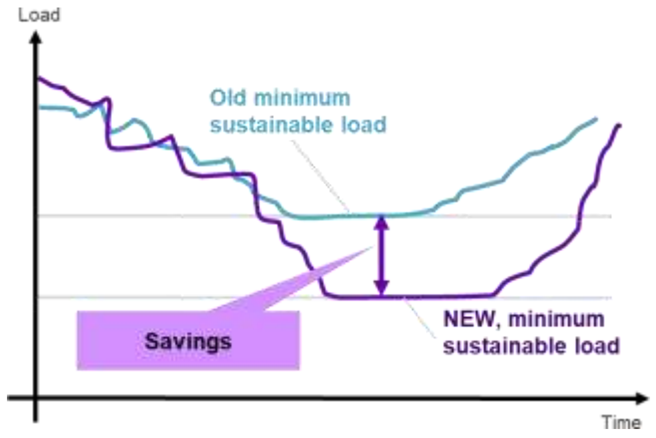
Efficiency
- Minimum Load Efficiency

Sustainability
- Carbon Footprint
- Operational Emissions

Intended Benefits

In times of low electricity prices, it can become lucrative for plants to reduce their minimum load level if the plant cannot be shutdown. However, many plants are not automated and optimized for this operation. Consequently, they do not exploit their capabilities and must operate at a higher than necessary minimum load level.

Omnivise Minimum Load Reduction reduces the minimum load which allows plants to limit losses at times of low electricity prices while keeping the impact on efficiency as low as possible.



Lower minimum load through improvements in open and closed loop control

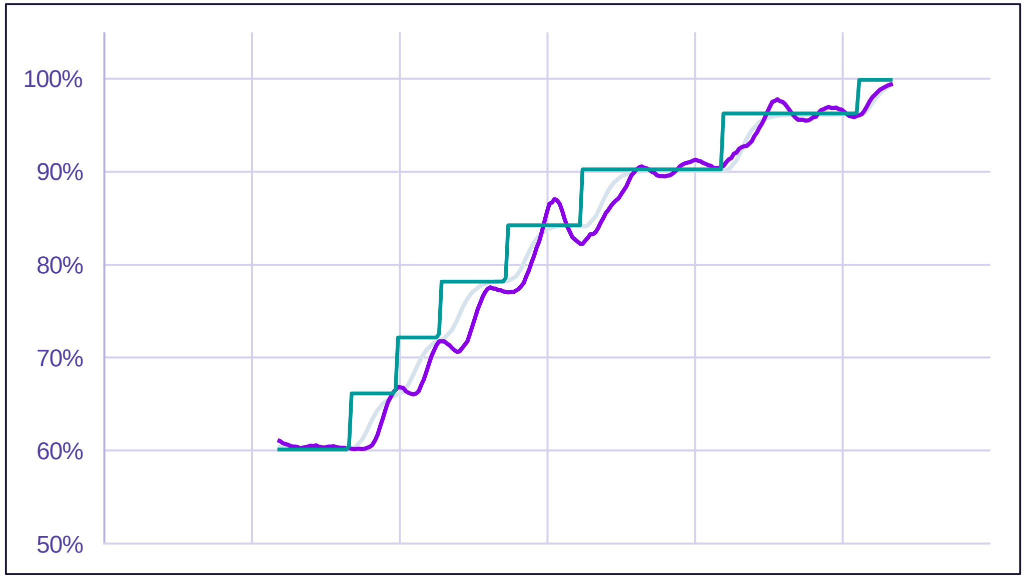
Scope

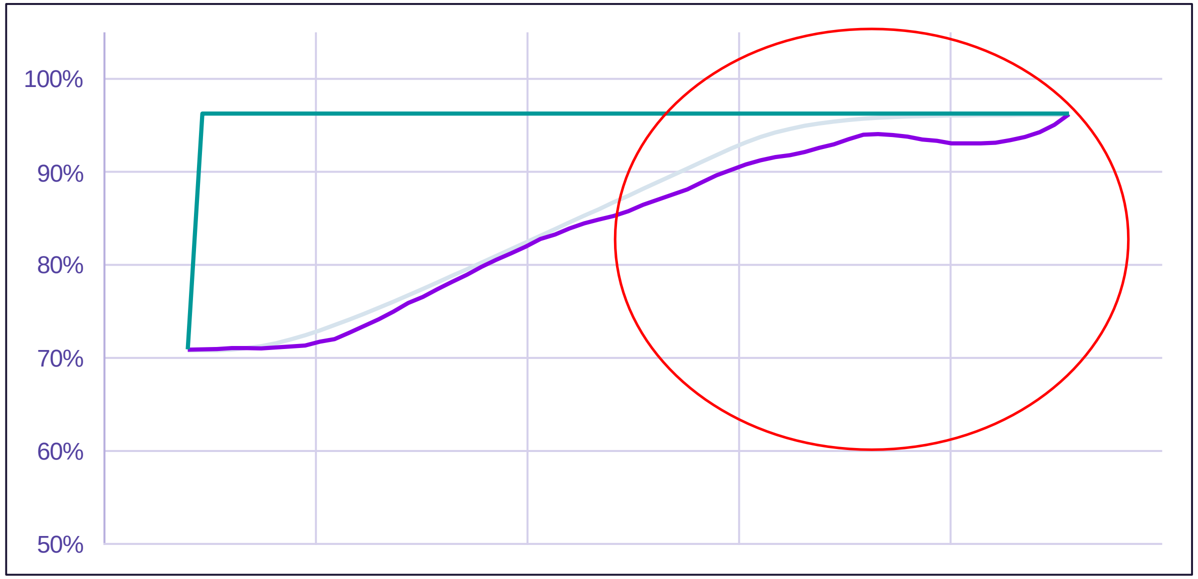
Omnivise Minimum Load Reduction is a turnkey solution consisting of

- Adaptation of lower-level closed loop controls by use of proven Siemens Energy automation concepts, e.g. for steam temperature control,
- Adaptation or addition of control sequences, e.g. automatic burner and mill scheduler or switchover of feedwater pumps
- Hardware & software with interface to control system (plant-dependent),
- Provision of additional instrumentation, e.g. for coal flow distribution (option)

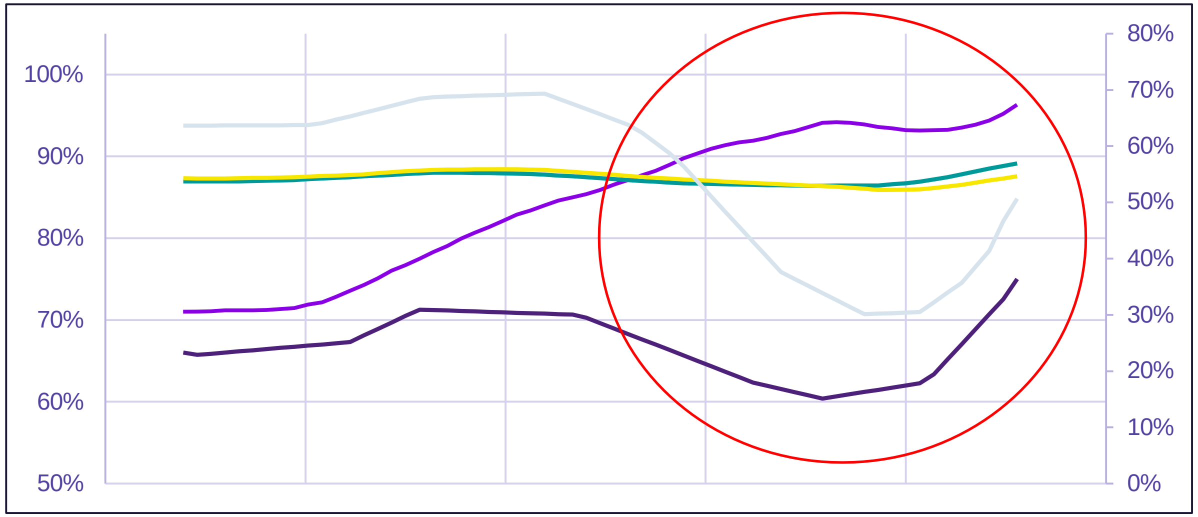
Ramps - What is existing in Plant !

Existing





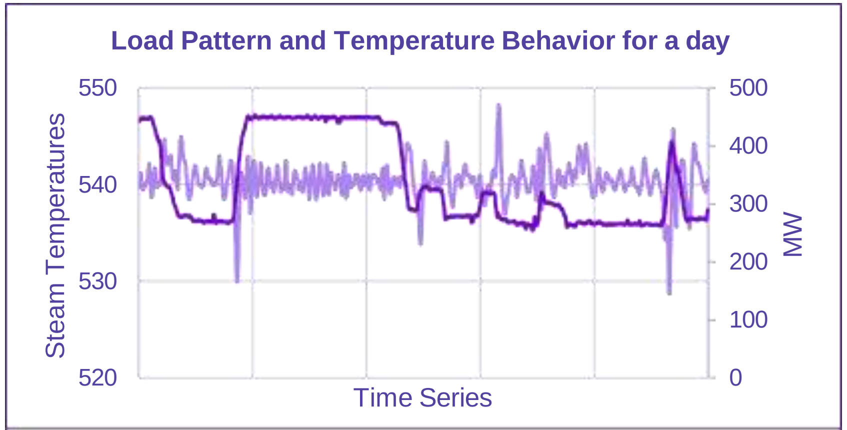
When tried to flex and given aggressive ramps

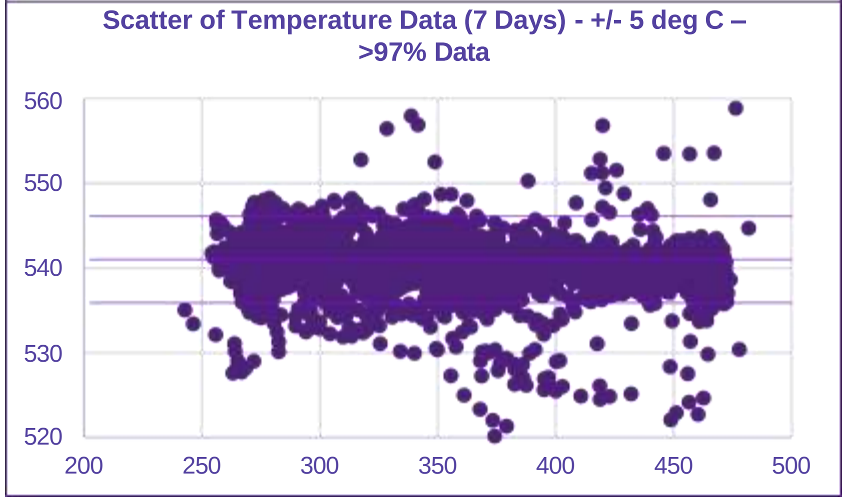


Ramp Rates

Plant Issues	Field Findings
Plant – 1 Metal Temperatures and Impact on component life	No monitoring methods for quality of ramps & fewer control measures available
Plant – 2 Steam Temperatures fluctuating heavily	Manual Interventions in most of the cases
Plant – 3 Low Ramp Rate in range of 0.5% to 1.4%	Non-coordinated or delayed controls
Plant – 4 Not the same ramp always	Operator to operator it varies and impacts in different manner with each ramps

Resolutions





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Temperature Optimizer

Increased efficiency thanks to higher steam temperatures using a dynamic Digital Twin

Est. Lead Time
6 Months

Min. Event Type
Minor

Fleet Experience
>10 Units

Power

- Power Output
- Power Saving

Efficiency

- Base Load Efficiency
- Transient Efficiency

Sustainability

- Carbon Footprint
- Operational Emissions

Intended Benefits

The control of the main and reheat* steam temperatures in steam generators is a complex control task due to the complex dynamic and non-linear interactions between combustion and water/steam control. Therefore, some plants cannot exploit the design limits of their main steam temperatures which reduces the plant efficiency.

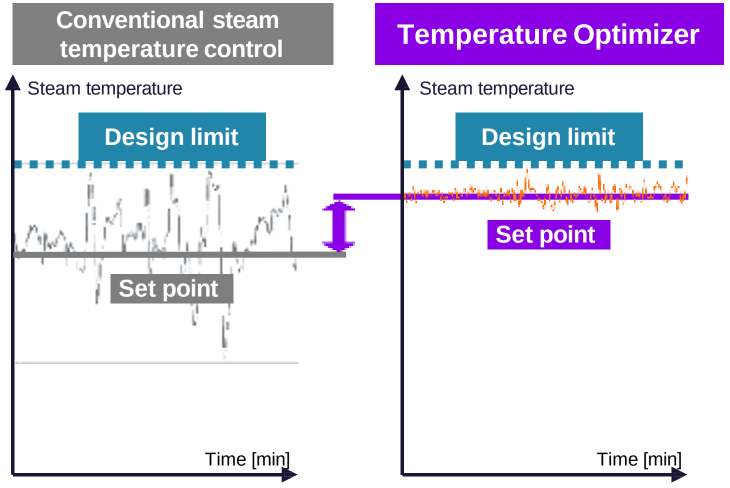
Omnivise Temperature Optimizer increases the steam temperatures closer to design limit and as a result the plant efficiency, which allows plants to

- Increase electricity revenues at base load and/or
- Reduce fuel costs at part load operation.

Scope

Omnivise Temperature Optimizer is a turnkey solution with a digital dynamic twin consisting of

- Server, interface to control system*, software,
- Robust, easy to parameterize, adaptive non-linear state-space control using a real-time dynamic Digital Twin to reduce main and reheat* steam temperature fluctuations.



Increased efficiency through higher steam temperatures

* *plant-dependent*

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Sootblower Optimizer

Increase efficiency and availability through optimal incremental sootblowing

Est. Lead Time
6 Months

Min. Event Type
Minor

Fleet Experience
>10 Units

Power

- Power Output
- Power Saving

Efficiency

- Base Load Efficiency
- Transient Efficiency

Sustainability

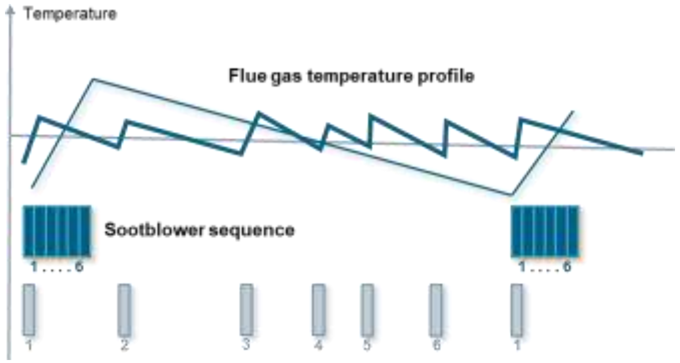
- Operational Emissions

Intended Benefits

Many coal-fired boilers face challenges from changing coal quality, slagging, and imbalanced or below design steam temperatures. Excessive soot blowing causes disturbances and even tube leaks. Manual, time-based and classical optimization strategies typically only have a limited impact.

Omnivise Sootblower Optimizer automates and optimizes soot blowing by incrementally controlling main boiler parameters which increases

- Plant efficiency, and
- Availability as unnecessary soot blowing is avoided



Optimum operation of individual sootblowers through incremental soot blowing

Scope

Omnivise Sootblower Optimizer is a turnkey solution consisting of

- Adaptation of sootblower open loop controls*,
- Server, interface to control system*, software,
- Incremental Sootblower Optimizer controlling main and reheat steam temperatures, reheat injections, and further main boiler parameters (option)

Various operator display demonstrate optimization effect

** plant-dependent*

Coal flow control avoids imbalances in coal flow, homogenizes combustion and improve emission

Task

Imbalance of coal flow between burners cause poor combustion and wall corrosion that means

- Lower efficiency
- More emissions
- More material stress

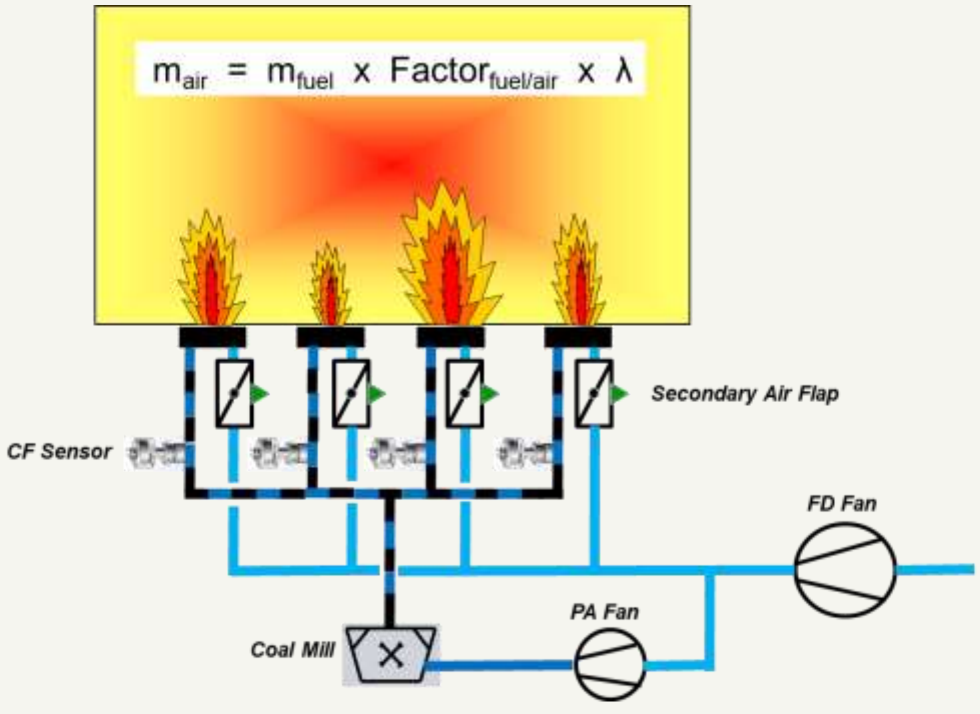
Solution

- Applying a microwave sensor system for coal flow measurement
- Air dampers controlled via SPPA-T3000 adjust air flow to coal flow
- Imbalances are equalized within a few minutes

Benefits

- Less CO at boiler walls, prevents boiler corrosion
- Less NOx,
- Higher efficiency
- Higher flexibility

High Flexibility | **High Efficiency** | **Low Emissions**



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Power

- Power Output
- Power Saving

Efficiency

- Base Load Efficiency
- Transient Efficiency

Sustainability

- Carbon Footprint
- Operational Emissions

Combustion Optimizer

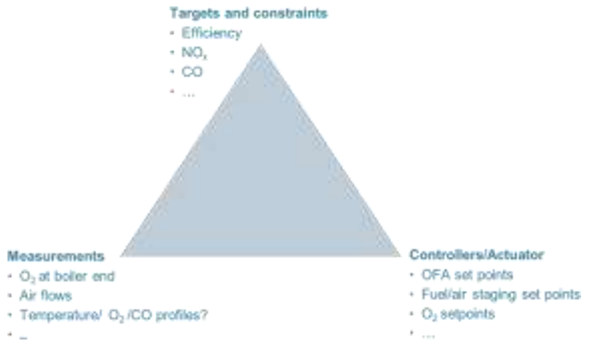
Increased efficiency and optimized CO_2, CO and NO_x emissions combining advantages of Advanced Process Control (APC) and Artificial Intelligence (AI)

Intended Benefits

Coal combustion with its multiple targets, constraints, measurements, and controllers, is a challenging task, especially when coal qualities and load ranges vary. Classical control and pure artificial intelligence approaches typically achieve only limited results.

Omnivise Combustion Optimizer uses a hybrid strategy combining the advantages of Advanced Process Control (APC) and Artificial Intelligence (AI) to optimize combustion which

- increases plant efficiency, and
- optimizes CO_2, CO and NO_x emissions



The challenge: complex combustion with multiple measurements, targets, constraints & controllers

Scope

Omnivise Combustion Optimizer is a turnkey solution consisting of

- Adaptation of lower-level closed loop controls through proven Siemens Energy automation concepts, e.g. for fuel/air control*,
- Server, interface to control system*, software,
- Combustion Strategy Manager using APC strategies exploiting the full design range
- Artificial Intelligence Module for combustion aspects without physical model (Option)
- Additional special measurements like laser-based or coal-flow measurement (option)

Hybrid combustion optimization using Advanced Process Control (APC) & Artificial Intelligence (AI)

* *plant-dependent*

Est. Lead Time 6 Months

Min. Event Type Minor

Fleet Experience >10 Units

Power

- Power Output
- Power Saving

Efficiency

- Base Load Efficiency
- Transient Efficiency

Sustainability

- Carbon Footprint
- Operational Emissions

Low Throttling

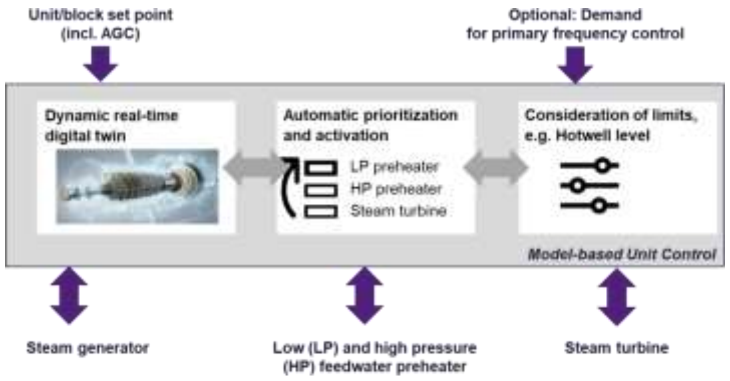
Increased efficiency
thanks to lower throttling losses in the steam turbine
using a dynamic Digital Twin

Intended Benefits

Many plants, especially if they provide primary frequency control, throttle the steam turbine in part and base load although the plant can be operated in sliding pressure mode. Advanced options to use low pressure (“Condensate Throttling”) or high pressure feedwater preheaters for temporary fast load changes are not used as they require a complex dynamic coordination.

Omnivise Low Throttling minimizes steam turbine throttling which allows plants to

- Increase electricity revenues at base load and/or
- Reduce fuel costs at part load operation.



Predictive management of steam generator, LP or HP preheaters * and steam turbine

Scope

Omnivise Low Throttling is a turnkey solution with a digital dynamic twin consisting of

- Plant assessment for sliding pressure mode and use of LP and HP preheater for temporary load increases
- Adaptation of closed loop controls through Siemens Energy automation concepts, e.g. condensate control*,
- Server, interface to control system*, software,
- Unit control implementation using a real-time dynamic Digital Twin predictively managing steam generator, LP & HP preheaters * and steam turbine to minimize steam turbine throttling

** plant-dependent*

Est. Lead Time
6 Months

Min. Event Type
Minor

Fleet Experience
>10 Units

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Omnivise Frequency Control

Increase revenues from provision of primary frequency control (PFC) using a dynamic Digital Twin

Est. Lead Time
6 Months

Min. Event Type
Minor

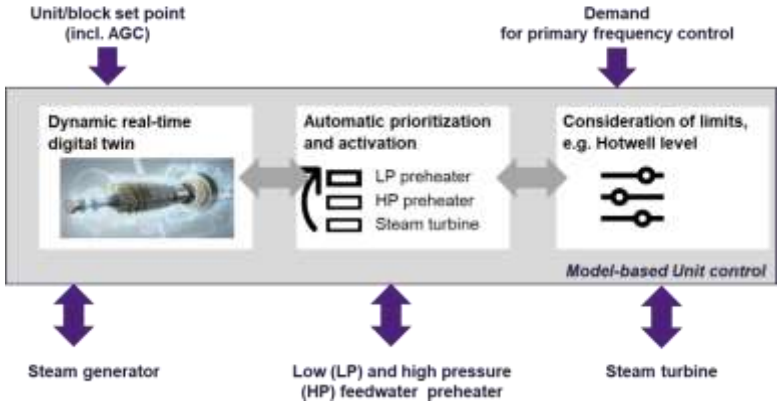
Fleet Experience
>10 Units

• Operational Flexibility

Intended Benefits

Typically, plants provide primary frequency control (PFC) by throttling their steam turbine valves which reduces efficiency. Complex dynamic coordination requirements prevent the use of advanced, efficient options for temporary fast load changes like low ("Condensate Throttling") or high pressure feedwater preheaters.

Omnivise Frequency Control allows plants to increase revenues for PFC, which usually outweighs efficiency losses by far.



Increased primary frequency control range through temporary use of LP or HP preheaters

Scope

Omnivise Frequency Control is a turnkey solution with a dynamic Digital Twin consisting of

- Adaptation of lower-level closed loop controls through proven Siemens Energy automation concepts, e.g. for steam temperature control*,
- Server, interface to control system*, software,
- Unit control implementation using a real-time dynamic Digital Twin predictively managing steam generator, LP & HP preheaters *, and steam turbine to increase PFC range

** plant-dependent*

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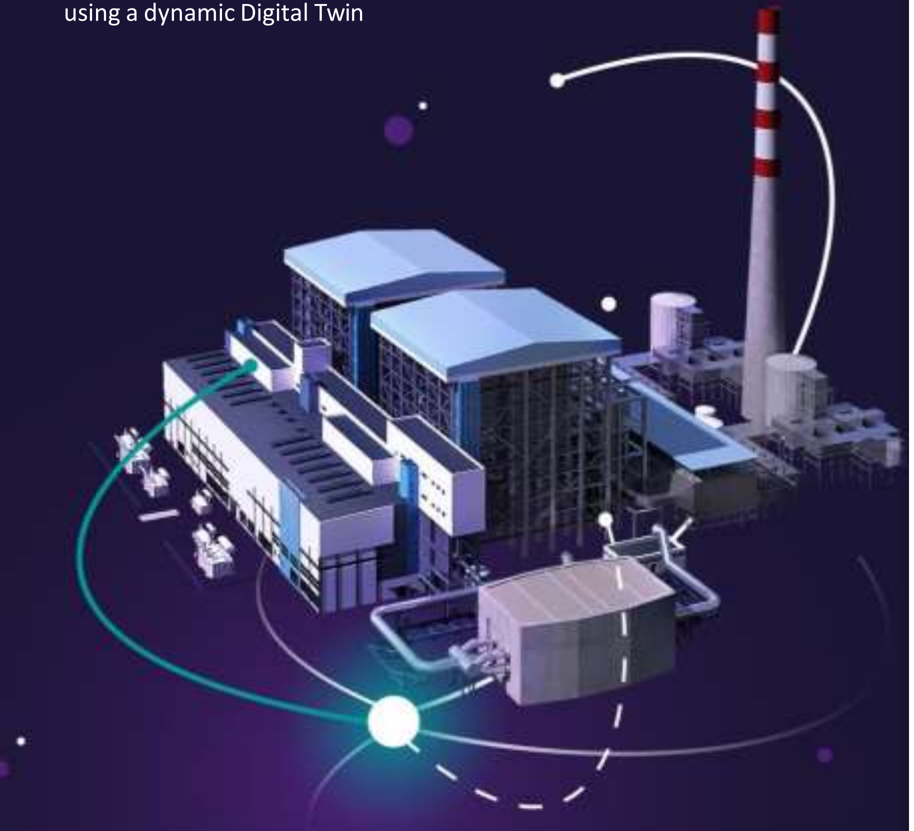
• Operational Flexibility

Omnivise Dispatch Control

Increase revenues from provision of secondary frequency control (SFC) or automatic generation control (AGC)
using a dynamic Digital Twin



Est. Lead Time
6 Months

Min. Event Type
Minor

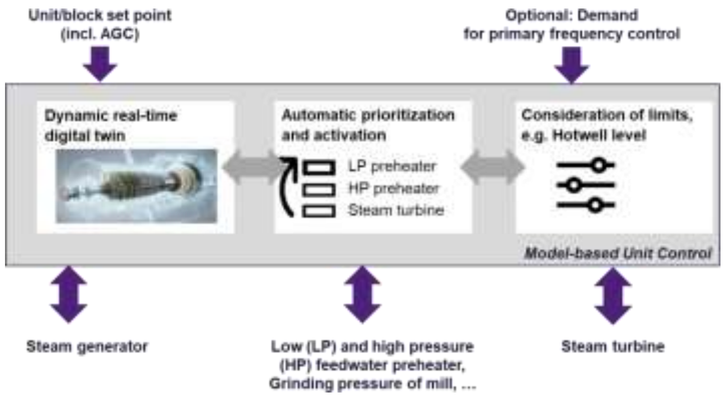
Fleet Experience
>10 Units

Intended Benefits

In some markets, plants are paid for providing secondary frequency control (SFC) or automatic generation control (AGC).

The complex dynamic interactions of steam generator, steam turbine and advanced options for temporary fast load changes like low pressure (“Condensate Throttling”) or high pressure feedwater preheaters, grinding pressure of coal mills * prevent some plants from exploiting their full dynamic potential.

Omnivise Dispatch Control allows plants to increase SFC or AGC revenues.



Predictive management of steam generator, low or high pressure feedwater preheaters, grinding pressure of coal mills * and the steam turbine

Scope

Omnivise Dispatch Control is a turnkey solution with a dynamic Digital Twin consisting of

- Plant assessment to use LP and HP preheater, grinding pressure of coal mills *, etc. for temporary load increases
- Adaptation of open and closed loop controls through proven Siemens Energy automation concepts, e.g. for steam temperature control *,
- Server, interface to control system*, software,
- Unit control implementation using a real-time dynamic Digital Twin predictively managing low or high pressure feedwater preheaters, grinding pressure of coal mills * and the steam turbine to increase SFC or AGC range.

** plant-dependent*

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Low Loss Start

Optimal automatic startups to generate more profits during start-up using predictive control with a dynamic Digital Twin

Est. Lead Time 6 Months

Min. Event Type Minor

Fleet Experience <10 Units

Efficiency

- Transient Efficiency

Flexibility

- Operational Flexibility

Reliability

- Starting Reliability

Intended Benefits

Starting up a power plant optimally is a challenging task with various factors like fuel and electricity prices, design limits and current plant conditions, e.g. cold/warm or hot start.

Slow and non-linear control loops like the steam temperature control make the automation of the optimal start-up a complex control problem which often requires manual operator interventions.

Omnivise Low Loss Start allows plants

- To reduce start-up losses by optimizing economic efficiency while limiting lifetime consumption, and
- to perform start-ups automatically

Scope

Omnivise Low Loss Start is a turnkey solution with a digital dynamic twin consisting of

- Adaptation of open and closed loop controls through Siemens Energy automation concepts, e.g. for drain step sequences or steam temperature control*,
- Server, interface to control system*, software,
- Predictive control to realize optimal set points for main control loops, e.g. for oil and coal, main steam pressure & temperatures, and steam turbine load

Plant design limits

Current thermal plant conditions

Current electricity and fuel prices

Predictive control

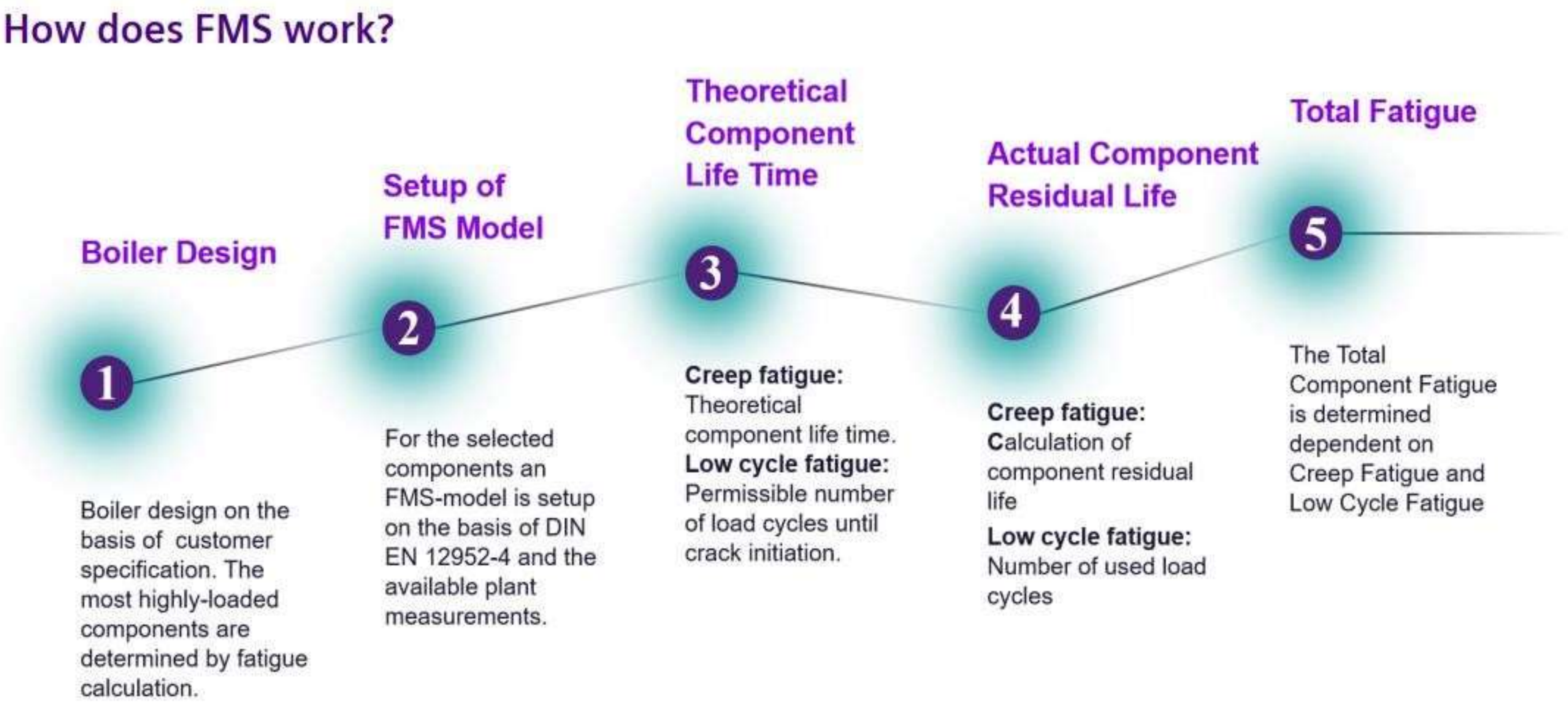
Implementation of optimal automatic start-ups

* *plant-dependent*

What FMS – Fatigue Monitoring System brings !

- Transparency on component fatigue behavior
- Utilization and planning of components and materials reserves
- Avoidance of Sudden component fatigue failures
- Reduced unplanned outages
- Extended boiler inspection intervals
- TUV SUD Certification for the Monitoring Software

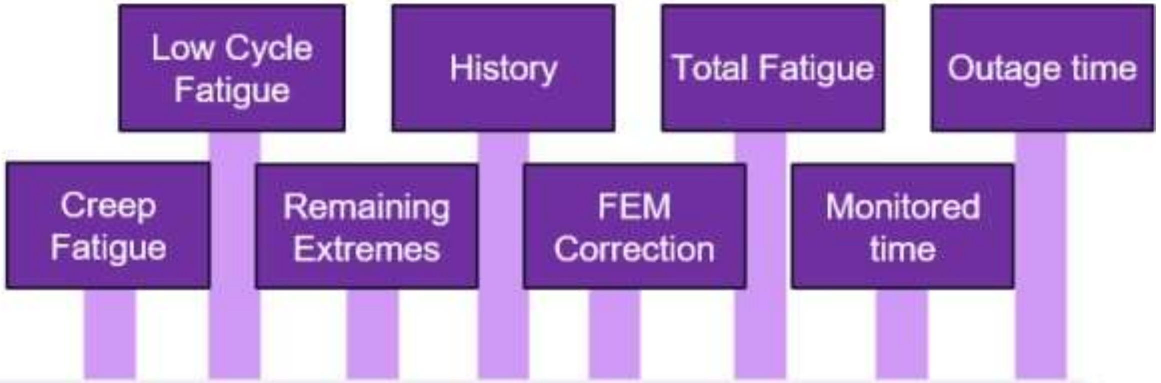
Fatigue Monitoring System



Fatigue Monitoring System

How does FMS look and feel?

Output table displays the status for each monitored component



Record type 1: Overview (Components)

Tag	Starttime	Endtime ZSE	Endtime DWE	ZSE [%]	DWE [%]	DWE-R [%]	E0 [%]	Ecorr [%]	**Eges [%]**	tZSE [h]	taZSE [h]
61HAD30BB001D|	2015-03-27 09:30:00	-	2020-09-14 03:12:41	-	0.6411	0.0071	0.000	0.000	**0.6482**	-	-
61HAD30BB001W|	2015-03-27 09:30:00	-	2020-09-14 03:12:41	-	0.2826	0.0064	0.000	0.000	**0.2890**	-	-
61HAH20BR002|	2015-03-27 09:30:00	2020-09-14 03:12:41	2020-09-14 03:12:41	4.5205	0.9678	0.0177	0.000	0.000	**5.5060**	47397.43	547.29
61HAH21BR003|	2015-03-27 09:30:00	2020-09-14 03:12:41	2020-09-14 03:12:41	4.5579	0.1760	0.0000	0.000	0.000	**4.7339**	47467.77	476.94

Fatigue monitoring

Record type 3: Creep fatigue (Service time)

Common Data

Component	06HAH40AC001_HO - SH PLATEN HEADER OUTLET (LEFT)
Starttime	2022-01-12 14:00:00
Endtime	2023-12-13 14:06:44
Type	Cylinder T-branch - butt joint, GMAW, no void
Material	SA-335 P22 (<= 60 mm)
Outside diameter (Parent part)	508 mm
Wall thickness (Parent part)	110 mm
Outside diameter (Branch)	51 mm
Wall thickness (Branch)	11 mm
Lifetime (Base)	0 h
Limits: cold starts / warm starts / hot starts	0 / 0 / 0
Sum operating hours	14785.46 h
Sum down-time	2015.63 h
Creep fatigue	0.92702 %

Operating hours per class

t [°C] -> p [bar]	350	350 400	400 450	450 460	460 470	470 480	480 490	490 500	500 510	510 515
< 10	1355.4	27.547	24.647	4.309	4.159	3.617	2.893	2.717	2.401	1.067
10 - 25	5.368	-	0.033	-	-	0.142	0.292	0.008	0.05	-
25 - 50	9.926	1.142	0.317	-	-	0.25	0.542	0.342	0.042	-
50 - 70	4.326	13.678	5.134	0.375	0.425	0.484	0.2	0.584	0.542	0.108
70 - 90	1.292	2.709	7.735	1.234	0.7	0.408	0.658	0.483	1.042	0.65
90 - 110	0.442	1.008	4.459	1.409	1.842	1.6	2.142	1.309	1.55	1.292
110 - 130	-	0.258	2.609	0.458	0.525	0.725	25.747	1.35	0.483	0.308
130 - 140	-	0.183	1.317	0.217	0.409	0.433	0.967	1.009	0.725	0.183
140 - 145	-	0.058	0.692	0.1	0.108	0.017	0.15	0.567	0.342	0.183
145 - 150	-	0.075	0.525	0.133	0.033	0.2	0.158	0.517	0.258	0.142
150 - 155	-	0.05	0.192	0.142	0.192	0.492	0.65	0.9	1.026	0.333
155 - 160	-	0.134	0.108	0.2	0.133	0.233	0.833	0.3	0.992	1.075
160 - 165	-	0.05	0.025	0.008	0.35	0.008	0.075	0.075	0.209	1.083
165 - 170	-	-	-	-	-	-	0.008	0.017	0.258	1.559
170 - 175	-	-	-	-	-	-	-	-	0.042	0.909
175 - 180	-	-	-	-	-	-	-	-	-	-
180 - 185	-	-	-	-	-	-	-	-	-	-
185 - 190	-	-	-	-	-	-	-	-	-	-
190 - 200	-	-	-	-	-	-	-	-	-	-
200 - 210	-	-	-	-	-	-	-	-	-	-
> 210	-	-	-	-	-	-	-	-	-	-
Hours	1376.7	46.893	47.792	8.586	8.877	8.61	35.315	10.177	9.961	8.893
Fatigue [%]	5e-32	9e-26	9e-22	2e-10	7.4e-9	9.5e-8	9.3e-7	9.2e-7	3.6e-6	1.9e-5

t [°C] -> p [bar]	515 520	520 525	525 530	530 535	535 540	540 545	545 550	550 555	555 560	560 565	565
< 10	0.867	0.867	0.55	0.909	1.175	2.251	20.896	0.225	-	-	-
10 - 25	0.033	0.017	0.017	0.058	0.075	0.125	6.093	0.025	-	-	-
25 - 50	0.025	-	0.025	0.042	-	0.067	0.042	-	-	-	-
50 - 70	0.234	0.033	0.033	0.058	0.225	0.117	0.292	0.008	-	-	-
70 - 90	0.684	0.884	1.242	1.75	1.083	1.134	1.084	0.367	0.067	-	-
90 - 110	1.317	1.142	2.292	2.025	3.076	2.359	5.178	4.636	0.033	-	-
110 - 130	0.283	0.592	1.017	1.425	1.759	1.967	12.344	4.117	0.042	-	-
130 - 140	0.05	0.534	0.758	1.75	1.859	2.717	13.361	2.675	0.183	-	-
140 - 145	0.25	0.183	0.458	1.834	8.243	13.961	66.955	30.624	0.259	-	-
145 - 150	0.175	0.217	0.992	12.969	26.157	42.54	281.06	109.68	0.7	-	-
150 - 155	0.358	1.217	4	25.58	86.486	259.46	1552.7	343.76	2.517	-	-
155 - 160	0.825	1.993	7.603	30.359	101.4	410.17	2507.4	453.01	5.701	0.259	-
160 - 165	4.859	9.819	24.195	72.741	159.55	349.53	1142.2	218.04	2.65	0.108	-
165 - 170	5.936	25.297	56.236	149.29	290.94	535.67	967.44	115.41	0.917	-	-
170 - 175	6.984	27.83	77.174	203.08	363.48	686.44	916.79	49.946	0.467	0.05	-
175 - 180	0.083	2.001	10.026	18.204	33.116	70.238	95.97	4.534	0.058	-	-
180 - 185	-	0.017	0.108	0.3	0.525	0.567	1.342	0.142	0.025	-	-
185 - 190	-	-	-	0.008	0.025	0.158	0.6	0.008	-	-	-
190 - 200	-	-	-	0.025	0.025	0.842	5.184	-	-	-	-
200 - 210	-	-	-	0.008	0.7	0.958	3.401	-	-	-	-
> 210	-	-	-	0.917	1.926	1.826	1.5	-	-	-	-
Hours	22.963	72.64	186.73	523.33	1081.8	2383.1	7601.8	1337.2	13.619	0.417	-
Fatigue [%]	1.5e-4	9.7e-4	0.004	0.017	0.048	0.148	0.578	0.129	0.002	9.1e-5	-

Record type 5: Low-cycle fatigue (Cycles)

Common Data

Component	06HAH40AC001_HO - SH PLATEN HEADER OUTLET (LEFT)
Starttime	2022-01-12 14:00:00
Endtime	2023-12-13 14:06:44
Type	Cylinder T-branch - butt joint, GMAW, no void
Material	SA-335 P22 (<= 60 mm)
Outside diameter (Parent part)	508 mm
Wall thickness (Parent part)	110 mm
Outside diameter (Branch)	51 mm
Wall thickness (Branch)	11 mm
Lifetime (Base)	0 h
Limits: cold starts / warm starts / hot starts	0 / 0 / 0
Low-cycle fatigue	0.78861 %
Uncomplete cycles list	0.33634 %

Cycles per class

t [°C] -> σ [N/mm²]	50	50 100	100 200	200 300	300 350	350 400	400 450	450 475	475 500	500 510	510 520	520 525	525 530	530 535	535 540	540 545	545 550	550 555	555 560	560 565	565
< 200	6	12	14	2	6	18	34	28	32	65	672	1427	3177	8236	2.99e4	4971	39	-	-	-	-
200 - 225	-	-	-	-	-	-	1	1	-	-	1	12	36	60	85	13	-	-	-	-	-
225 - 275	-	-	-	-	1	-	-	-	1	1	5	8	33	62	54	7	-	-	-	-	-
275 - 325	-	-	-	-	-	-	-	-	-	-	3	8	13	32	21	6	-	-	-	-	-
325 - 375	-	-	-	-	-	-	-	1	1	-	1	5	7	10	8	1	-	-	-	-	-
375 - 425	-	-	-	-	-	-	-	-	1	-	1	2	3	3	1	2	-	-	-	-	-
425 - 450	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-
450 - 500	-	-	-	-	-	-	-	1	-	1	-	-	-	1	-	-	-	-	-	-	-
500 - 530	-	-	-	-	-	-	-	-	-	2	1	-	-	-	-	-	-	-	-	-	-
530 - 570	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-
570 - 600	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
600 - 650	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
650 - 700	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
700 - 750	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
750 - 800	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
800 - 900	-	-	-	-	1	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-
900 - 1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1000 - 1500	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-
1500 - 2000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2000 - 2500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 2500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cycles	6	12	14	2	8	18	36	38	37	69	684	1462	3269	8404	3.01e4	5000	39	-	-	-	-
Fatigue [%]	6.0e-5	1.2e-4	1.4e-4	2.0e-5	0.024	1.8e-4	0.025	0.114	0.095	0.01	0.012	0.018	0.038	0.092	0.307	0.052	3.9e-4	-	-	-	-

Successes in Technical Min assessment and Digital based flexibility Interventions in India

NTPC Dadri 500 MW

- Interventions implemented to automate load reduction to 40% and ensure stable operation
- Enhanced Unit Control
- Reheat / Flue Gas / Main Steam Temperature Control
- Fatigue Monitoring System
- Mill Scheduler
- Replacing of the feed water recirculation valve by a control valve

Tata Power Trombay 500 MW

- Implementation of “Dispatch Control” and “Temperature Optimizer”
- Improve the flexibility of the plant

Successes in Technical Min assessment and Digital based flexibility Interventions in India

SIEMENS energy

Mundra Thermal Power Station – 830 MW

- Combustion Optimization

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