Sharing the Journey : Supporting Plants in Achieving Flexibility

Ian Rebello

Siemens Energy, May 2026 Lucknow

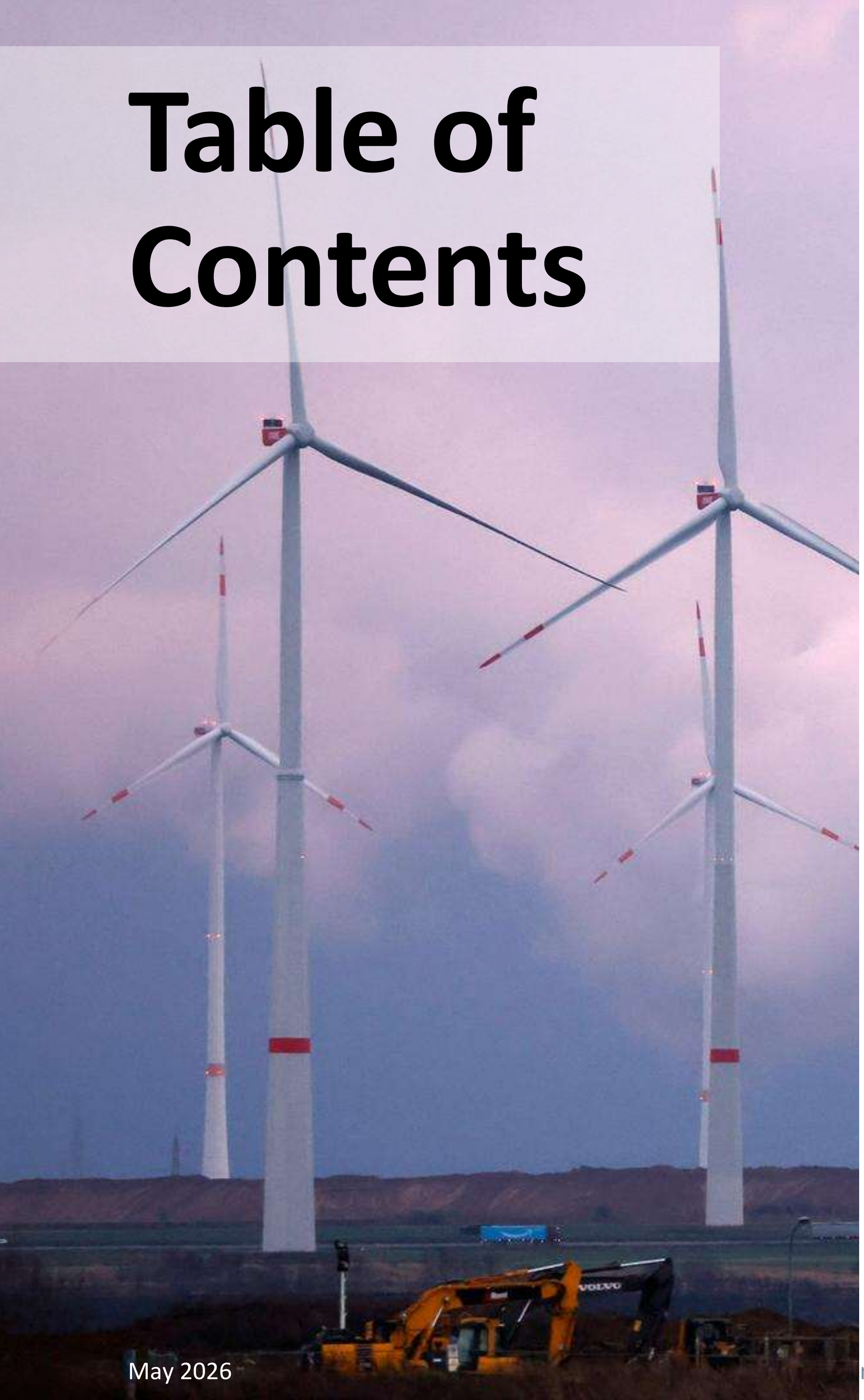

Table of Contents

Challenges in Integrating Renewable Energy into the Indian Power Grid

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Rising Curtailment: Clean Power Is Being Wasted

Several 2026 news reports highlight that India is increasingly curtailing (switching off) renewable generation due to grid constraints:

India curtailed ~31 GW of renewable capacity in Q4 FY26 due to inadequate transmission and system flexibility. [business-s...andard.com]

In the same quarter, 27 GW solar + 4 GW wind were curtailed, with additional curtailment via balancing mechanisms. [energy.eco...atimes.com]

Companies like ReNew have had to cut up to 15% of solar output because grids cannot absorb peak daytime generation. [msn.com]

Grid Stability and Flexibility Challenges

High renewable penetration is making the grid more volatile and harder to manage:

Increased solar penetration leads to voltage fluctuations and frequency instability. [pv-magazine.com]

Grid operators struggle due to limited flexibility of coal plants, which cannot ramp down fast enough. [downtoearth.org.in]

Even during high renewable output, coal continues to dominate because it's needed for stability. [outlookbusiness.com]

👉 **Implication**

India needs a **flexible grid (smart grids, demand response, flexible thermal plants)** to integrate renewables effectively.

Planning by CEA for Generation Companies
Notification dated 30 Jan 2023

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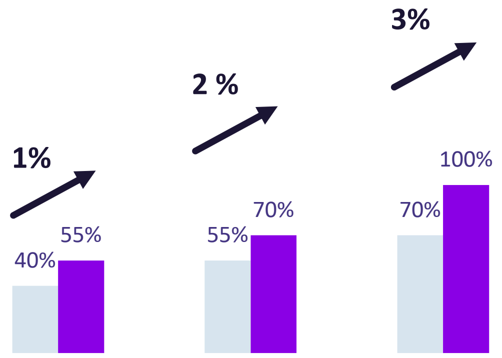
New Technical Minimum
40 %



Load Ramps

"Improved Control Systems" Phase 1

> 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.

IMPLICATION ON GENERATION COMPANIES

Generation Companies are expected to conduct MIN Load tests & evaluate their units for potential to meet the CEA requirements

Generation companies are expected to implement the necessary interventions to meet the CEA notification requirements as per the phasing plan , which has been notified by CEA in Dec'23.

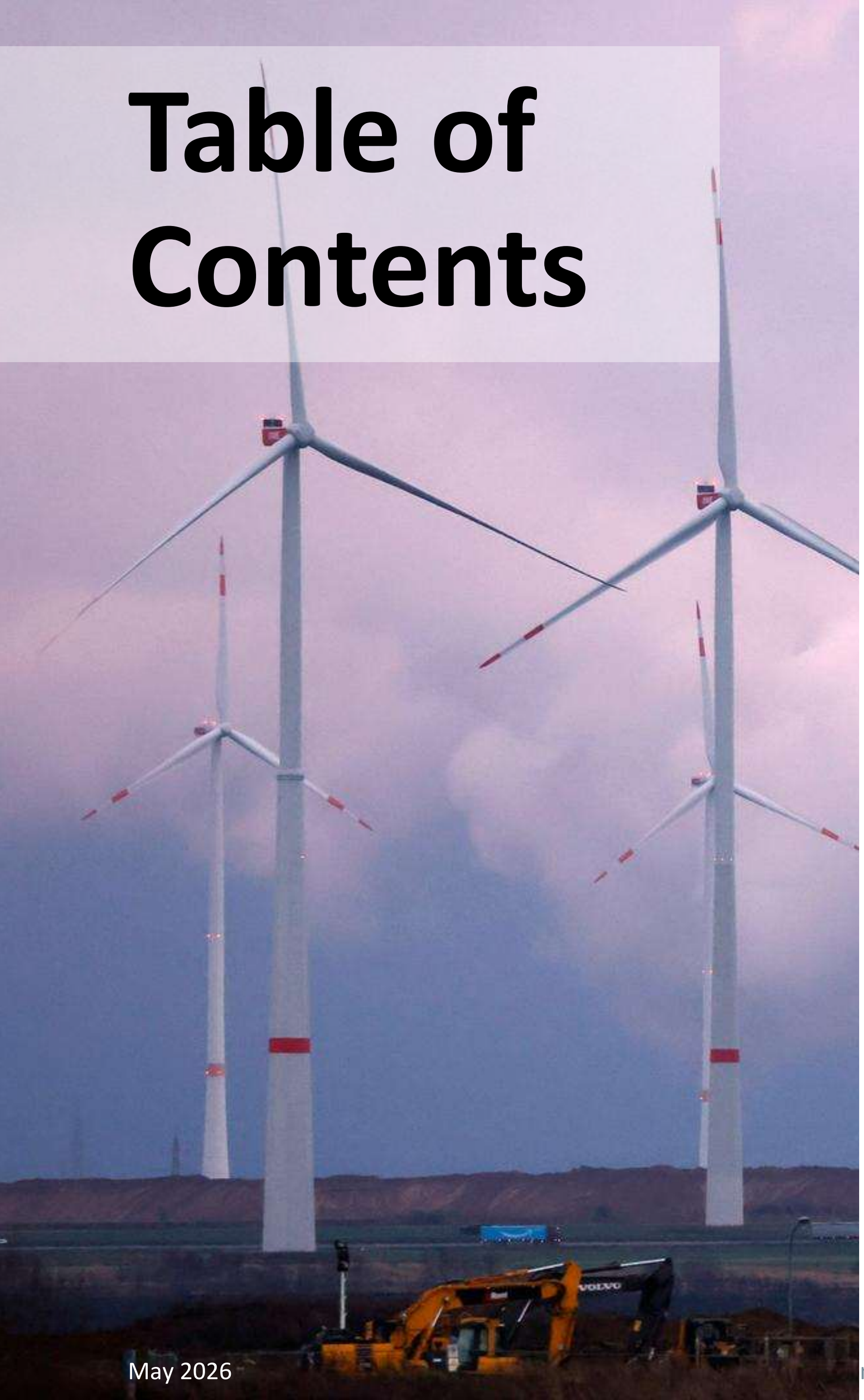


Table of Contents

Siemens Energy Role in supporting Flexible operation of Thermal Plants in India

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CEA conducts multiple tests for MIN Load operation , ramps etc.	Siemens Energy participated at 3 power plants – NTPC Dadri 500 MW (40%), MPL Maithon – 525 MW (36%) & DVC Andal – 500 MW (32%)
Compilation of reports & strategies for Flexible operation	Siemens Energy supported CEA with reports and analysis for the units tested.
CEA framed the phasing plan for implementation of Flexible operation	4 Phases have been identified from 2024 – 2030 based on various criteria – age, pithead , control systems, mill technology etc.
Phase 1 in progress – 91 plants **July 2024 – June 2026** Phase 1 targets newer supercritical units requiring minimal modifications due to advanced design standards. ***Source CEA***	Siemens Energy has conducted MIN load & ramp tests at 10 plants. We are participating in about active enquires for about 18 units. We have implemented Flex solutions at 4 plants. Major customers – Tata Power, GSECL, MahaGenCo, OPGC, Sembcorp , NLC, CSPGCL , Adhunik,JSW, DVC, J P Power Ventures among others. Siemens Energy team comprises of experts in India who test , engineer & commission the solutions backed with support from HQ as required

Siemens approach for Min Load (40%) & ramp tests
There is no One Size Fits All !!!

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Answering Questionnaire

Information about thermal state of plant (degradation level), existing automation level, flamer scanner, combustion stability, start-up procedure etc. have to be provided

Providing of Process Data

Process data from one cold start-up, one ramp down to min load and one ramp up to full load will be analyzed from Siemens-Energy.

Alignment on min load tests

Siemens Energy suggests based on the provided information and the result of the data analyzation a test procedure to reduce min load.

Reducing min. load on site

Siemens Energy experts and the operators from the power plant reduce the min load according the agreed test procedure until first obstacle occurs.

Implementation and automation of min. load

Siemens Energy implements the identified measures to automate the load reduction and secure a stable operation during min load

Test Plans for Plant assessment

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Test Overview

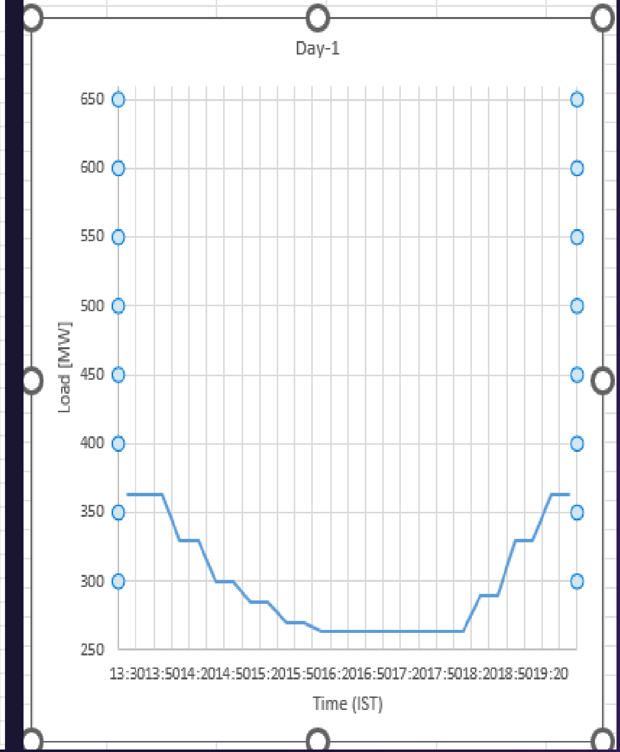
Date	Weekday	Test	Load
To be decided	Day-1	Minimum Load Test	264 MW
	Day-2	Minimum Load Test	264 MW
	Day-3	Load Ramp Test	Between 264 and 660 MW
	Day-4	Reserve Day	

Load Schedule

Cust XXX

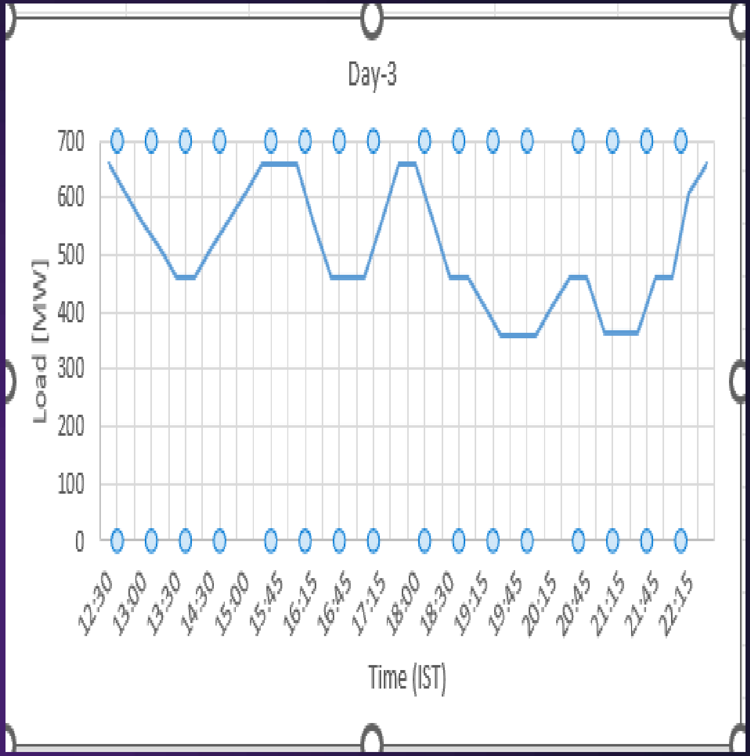
Day-1

Time (IST)	Time (CET)	Load [MW]	rel Load	% Load
13:30	9:00	363	0.55	55%
13:40	9:10	363	0.55	
13:50	9:20	363	0.55	
14:00	9:30	330	0.50	
14:20	9:50	330	0.50	
14:30	10:00	300	0.45	
14:50	10:20	300	0.45	
15:00	10:30	285	0.43	
15:20	10:50	285	0.43	
15:30	11:00	270	0.41	
15:50	11:20	270	0.41	
16:00	11:30	264	0.40	40%
16:20	11:50	264	0.40	
16:30	12:00	264	0.40	
16:50	12:20	264	0.40	
17:00	12:30	264	0.40	
17:20	12:50	264	0.40	
17:30	13:00	264	0.40	
17:50	13:20	264	0.40	
18:00	13:30	264	0.40	
18:20	13:50	290	0.44	
18:30	14:00	290	0.44	
18:50	14:20	330	0.50	
19:00	14:30	330	0.50	
19:20	14:50	363	0.55	
19:30	15:00	363	0.55	



Day-3

Time (IST)	Time (CET)	Load [MW]		MW/min
12:30	8:00	660	0.5% Ramp rate	3.3
12:45	8:15	610		
13:00	8:30	560		
13:15	8:45	510		
13:30	9:00	462	70% Load	
14:15	9:45	462		
14:30	10:00	510		
14:45	10:15	560		
15:00	10:30	610		
15:30	11:00	660		
15:45	11:15	660		
16:00	11:30	660	1% Ramp rate	6.6
16:15	11:45	560		
16:30	12:00	462	70% Load	
16:45	12:15	462		
17:00	12:30	462		
17:15	12:45	562		
17:30	13:00	660		
18:00	13:30	660	1 % or higher Ra	9.9
18:15	13:45	560		
18:30	14:00	462	70% Load	
19:00	14:30	462	0.5% Ramp rate	3.3
19:15	14:45	410		
19:30	15:00	360	55% Load	
19:45	15:15	360		
20:00	15:30	360		
20:15	15:45	410		
20:30	16:00	462		
20:45	16:15	462	1% Ramp rate	6.6
21:00	16:30	363		
21:15	16:45	363	55 % Load	
21:30	17:00	363		
21:45	17:15	462		
22:00	17:30	462	1.5% Ramp rate	9.9
22:15	17:45	610		
22:30	18:00	660		



Challenges in complying with CEA Guidelines: Insights from Siemens Energy's Testing Experience

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210 MW and below	250 / 500 / 600 MW unit	660 MW and above
Combustion / Flame Issues Part Load Controls Issues Lower SH/RH steam temperatures at Part Load Fan Stalling	Metal Temperature Issues Drum Level Control and few other Control Loops. Steam Temperatures Issues	Near to Benson Point Operation Intermittent water in separator tank vessel Metal Temperature Issues 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**
- **Field components overhaul – damper, valves etc.**

Advanced Process Controls and Digital Technologies: Addressing Operational Challenges in Flexible Thermal Power Plant Operations

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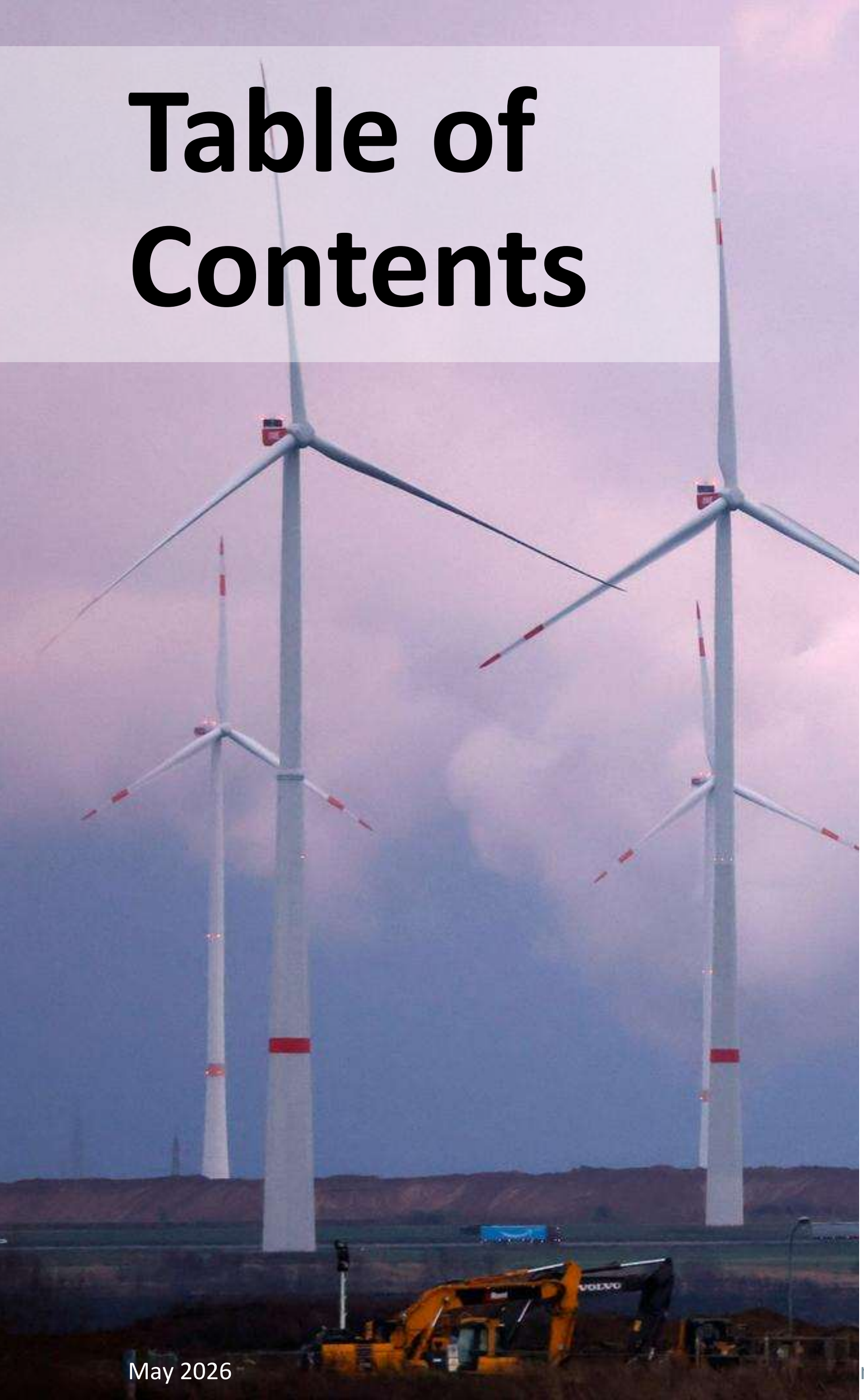
Challenges	Solutions	Benefits
Low Ramp Rate Combustion / Flame issues Operator interventions	Enhanced master controls Low load controls tuning	Higher ramps Reduced operator intervention Better efficiency
Aux Power Single Stream Operation	Auto Cut In/Off of Auxiliaries Mill Scheduler	Reduced aux power Reduced operator intervention Better efficiency
Impact on components Unscheduled outage	Fatigue Monitoring System Life consumption - online	Low stress operations Shutdown planning

Table of Contents



Delivering Excellence: Choosing the Optimal Approach for Every Solution to Boost Plant Performance

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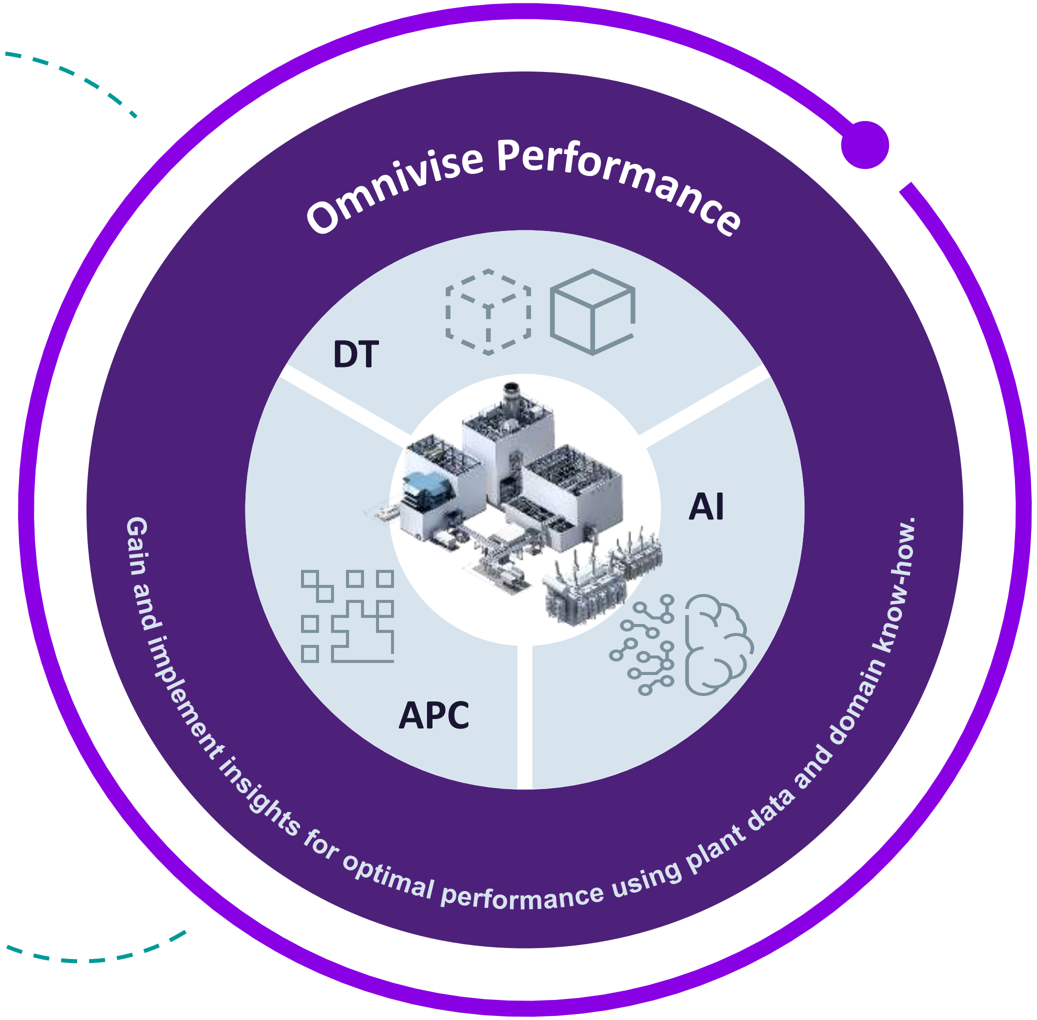
Digital Twin

Digital twins use equations to model various plants aspects, e.g. conservation of mass and energy in Digital Thermal Twins to add background knowledge to plant data

Advanced Process Control

Dynamic digital twins used in non-linear model predictive control (NMPC), state space control to exploit limits beyond historic operation



Artificial Intelligence

Machine learning, neural nets, fuzzy logic to exploit historic plant operation

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Omnivise Performance: Steam Power Plant

A suite of solutions to help operate a steam power plant at its most profitable operating point, leading to greater flexibility, higher efficiency, and low emissions.

Est. Lead Time
3 Months

Min. Event Type
Minor

Fleet Experience
> 50 Units

Sustainability

- Operational Emissions

Efficiency

- Base Load Efficiency
- Transient Efficiency

Flexibility

- Operational Flexibility

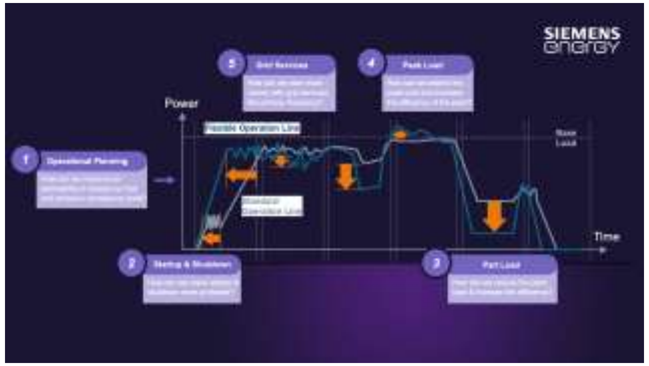
Intended Benefits

- **Improved start-up/shutdown:** Fast Start, Low Loss Start, Hot Start on the Fly
- **Extended peak load operation:** Maximum Load Plus
- **Reduced part load operation:** Minimum Load Reduction
- **Higher Efficiency and lower emissions at all load ranges:** Combustion Optimizer, Sootblower Optimizer, Temperature Optimizer, Best Point
- **Improved Grid Services:** Frequency Control, and Dispatch Control

All solutions can be implemented in plants with and without Siemens turbines.

All solutions can be implemented in plants with and without Siemens control systems.

All solutions are also part of Flex-Power ServicesTM .



Business Outcomes

Scope

Utilities are focused on increasing revenues while minimizing operational costs to deliver low-cost, high quality energy to their customers and to serve ancillary services markets. Using Advanced Process Control (APC), physics-based models and artificial intelligence (AI) without major changes to mechanical equipment is one of the options to increase your plant's profitability.

With Siemens Energy Omnivise Excellence & Sustainaiblity, you can adapt plant operations to your current requirements which increase profitability during start-ups/shutdowns, provision of grid services and part and peak load operation.

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Power
- Power Output
- Power Saving

Efficiency
- Base Load Efficiency
- Transient Efficiency

Sustainability
- Carbon Footprint
- Operational Emissions

Temperature Optimizer: Steam Power Plant

Optimize control actions by the various final control elements used for temperature control during startup and over the entire load range.

Est. Lead Time
3 Months

Min. Event Type
Minor

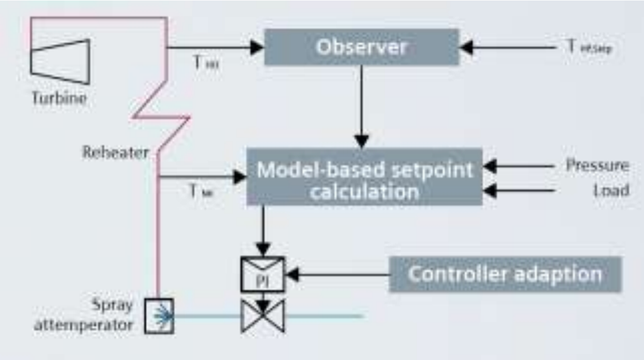
Fleet Experience
> 10 Units

Intended Benefits

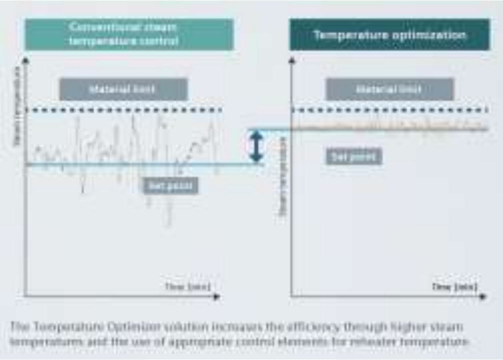
- Increase efficiency due to higher steam temperatures
- Reduction in reheater attemperation

Scope

- Robust, easy to parameterize and adaptive state space controller with observer
- Use of entire control range through to injection into saturated steam (when needed)
- Use on startup/shutdown and over the entire load range
- Use of flue gas recirculation and biflux or triflux valves to control reheat steam temperature



Workflow



Benefit

Total Plant
CP3-20-0001-BP-EN-01-000

AL:N, ECCN: EAR99 / 5-20-DI0053-01
Published on August 18, 2020

Boiler Fatigue Monitoring System (FMS)
Life cycle of Components Online Evaluation--Possible

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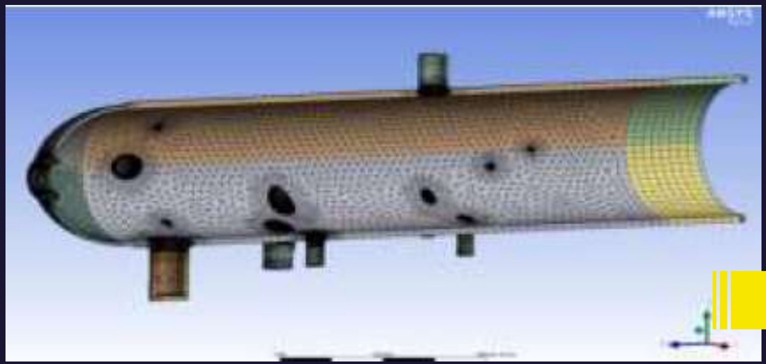
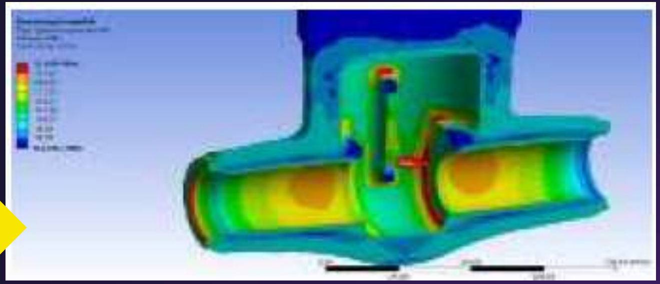
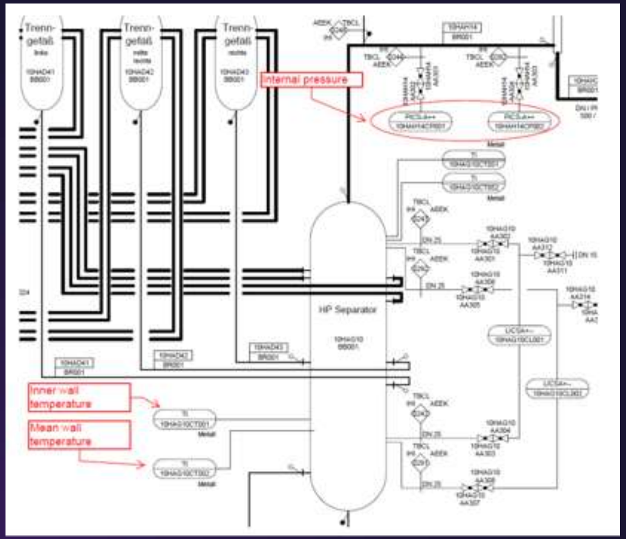
Online Fatigue calc and evaluation of lifetime limits and stresses







Component under Fatigue caused by Thermal cycling

How much fatigue is it ?

Optimization of process to regulate the parameters

Don’t Guess when you can measure !!!

Affected components:

Headers, Drums, Separator.

Attemperators, Piping

New fatigue control & Monitoring → Higher flexibility with check on Material Life

How Fatigue Monitoring System (FMS) benefits power plants

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Transparency

Continuous recording of particular plant data, continuous documentation of component load and component fatigue

Damage Prevention

Real time evaluation recognizes high-wear operation modes and informs on actual component residual life.

Optimized planning

Optimum harmonization of boiler outage with outage of other plant components

Safety

Avoidance of sudden component fatigue failure

Cost-efficiency

Utilization of component material reserves

Compatibility

With SPPA-T3000 or any other plant control system through OPC interface

Any Fleet Make
Performance Packed
Decarb
Locally Controlled

Performance Monitoring using best-in class digital thermal twin

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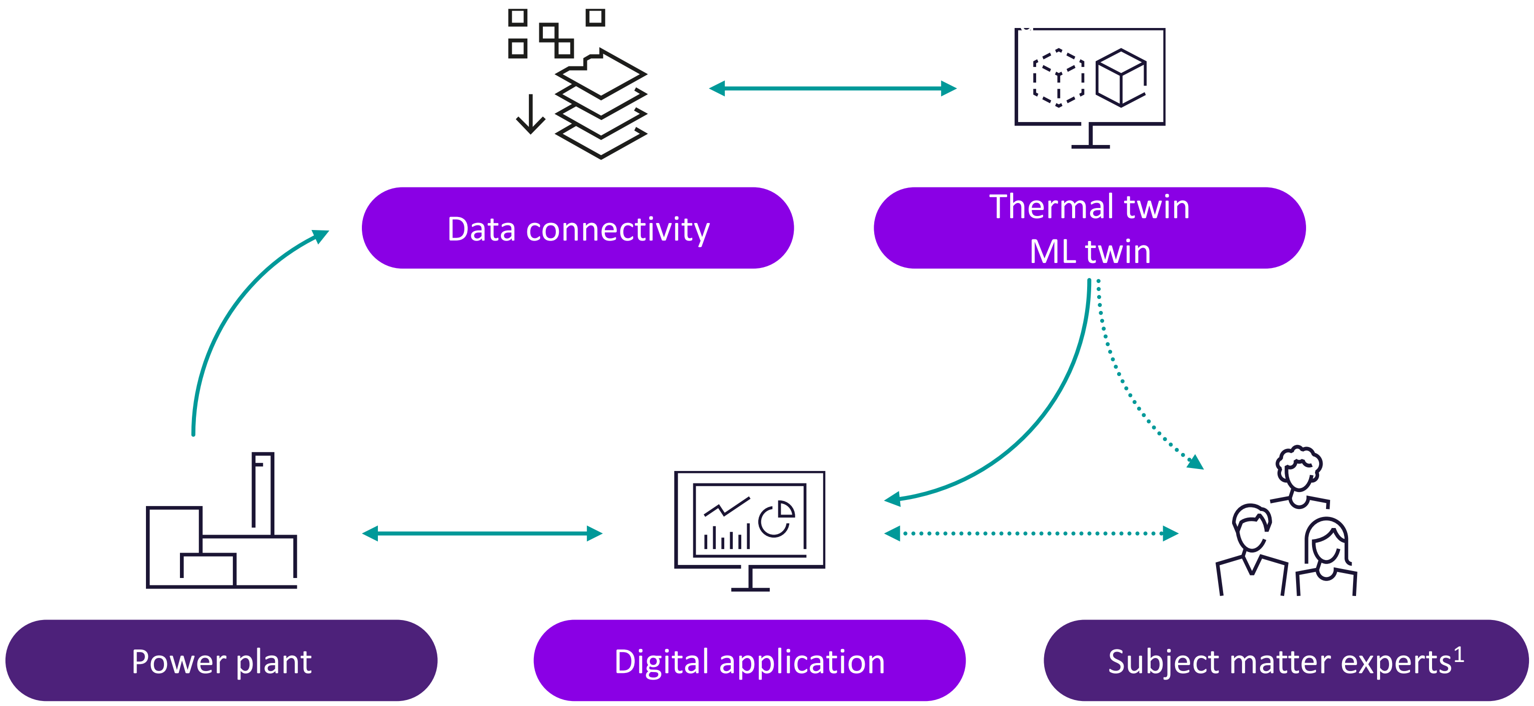
Product description

- Thermodynamic models ideal state plants performance “the digital thermal twin”.
- Deviation from the ideal state can be identified by customer or with help of Performance expert

Key Features

- Real time performance monitoring
- Real time financial impacts and optimize plant economics
- Power plant individual equipment degradation prediction for extended period of time
- Optimize your capex and opex budget
- Consolidated dashboard view on a user-friendly platform

We provide you with supplemental decision- making resources.



You can observe and study the performance of your plant via our industry leading digital applications

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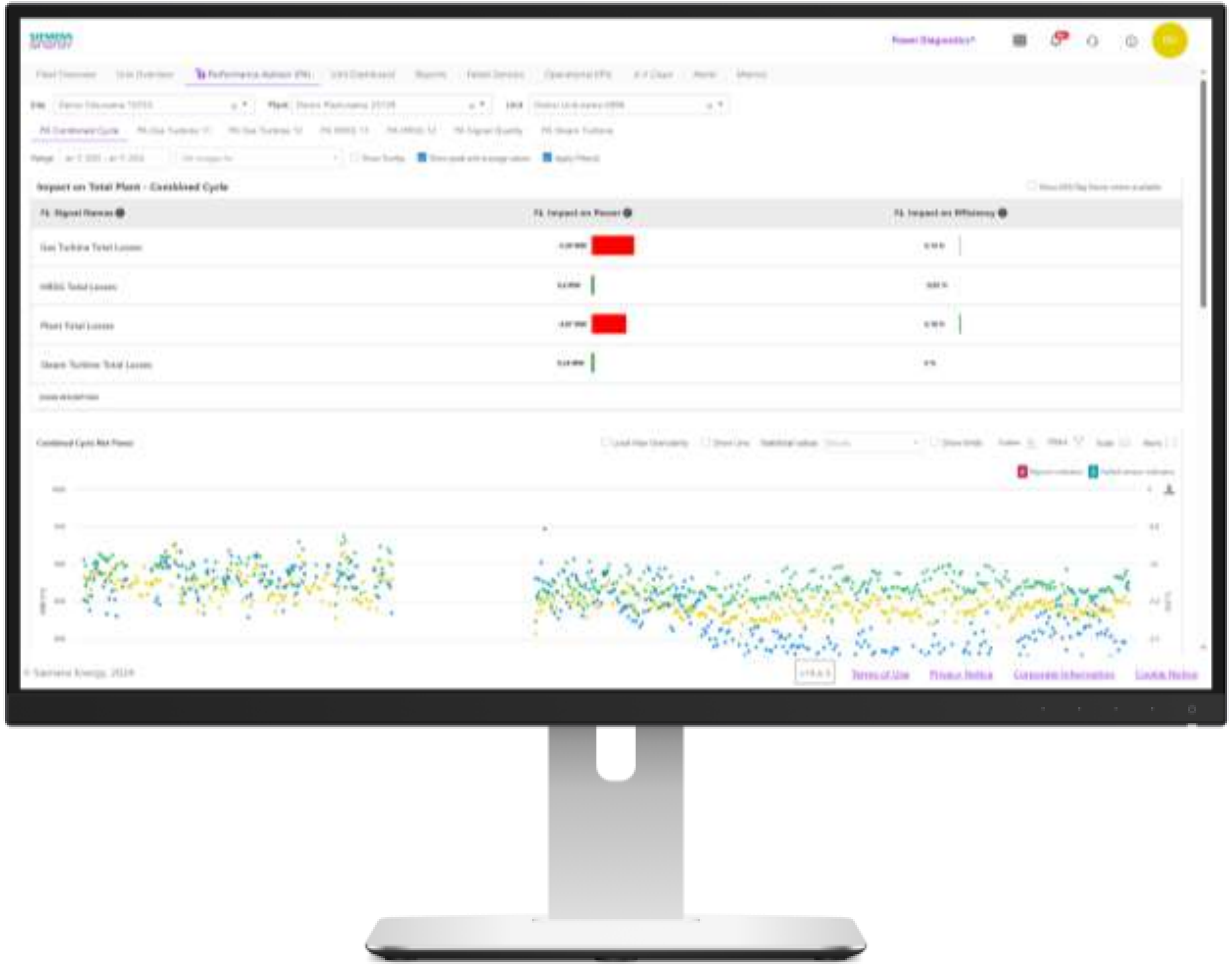


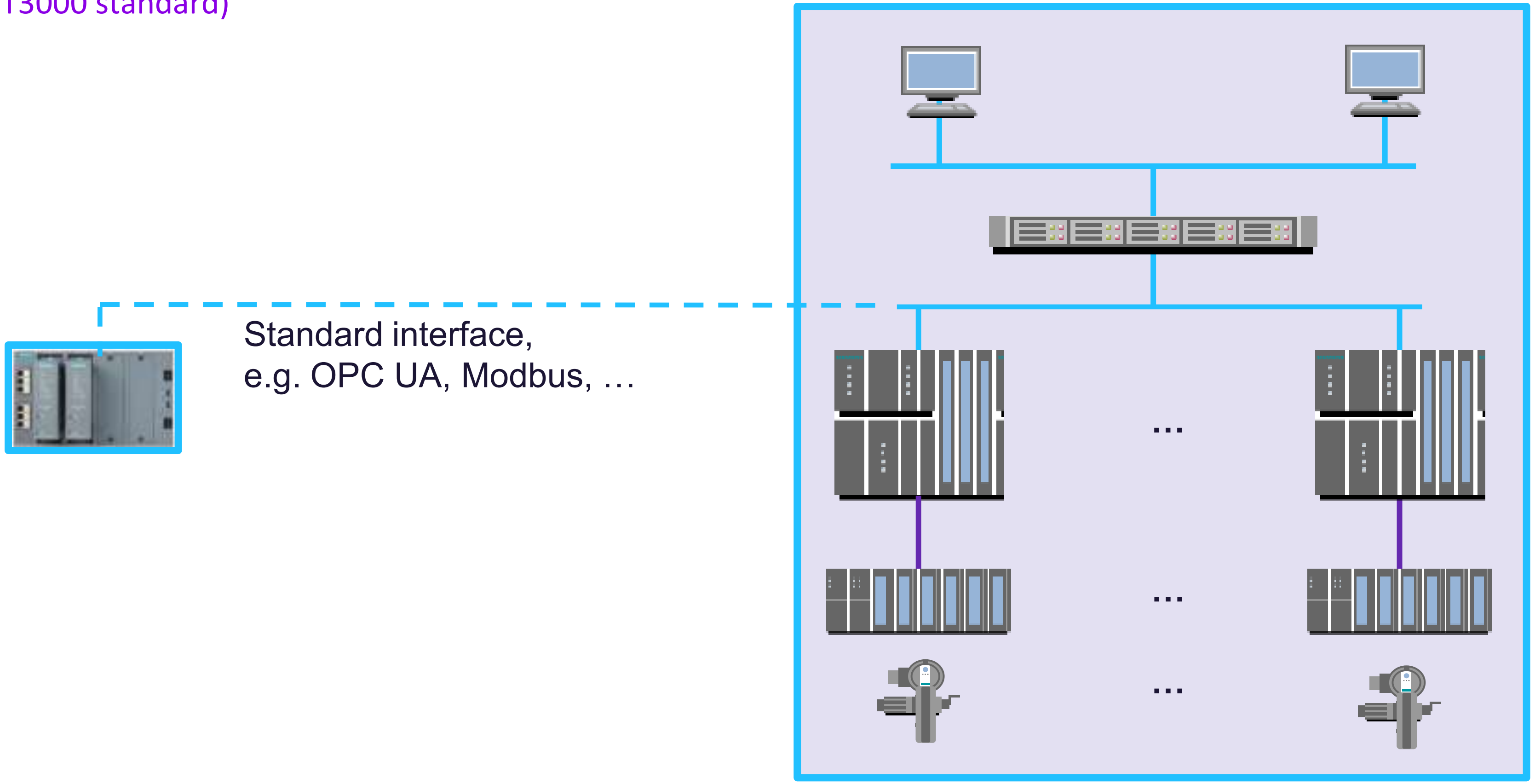
- **Compare actual vs. expected digital twin values** for a quick overview of controllable losses
- **Communicate effortlessly with our performance experts online** and refer back to historical actions and outcomes
- **Reconcile & validate sensor measurements** according to VDI 2048*
- **“What-if” calculations** for:
  - Sensitivity analysis for different parameters
  - Load dispatch, e. g. for next day
  - Determination of optimum operational conditions

* VDI 2048 German Guideline (publically available)

Easy hardware integration: Interface to plant control system using standard interfaces

Omnivise
Performance Server
(SPPA-T3000 standard)

DIstributed control system
(SPPA-T3000 or 3rd party)



Siemens Energy Recommendations (Phase 1)

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Basic Solutions

- Existing loops fine tuning at low loads
- Temperature Optimizer
- Enhanced Unit Controls – Faster ramp / optimized combustion.

Minimum APC solutions

Additional solutions to reduce operator intervention , reduce APC, improve efficiency

- Mill Scheduler
- Soot blower Optimizer
- Single Steam operation – Auto shift
- Condensate throttling – primary frequency response.

Operator comfort , improved efficiency

Monitoring

- FMS - life consumption Transparency, best mode operation, outage planning
- Performance Monitoring – Digital twin based on thermodynamic model , actual vs desired.

Higher Focus , Outage Planning

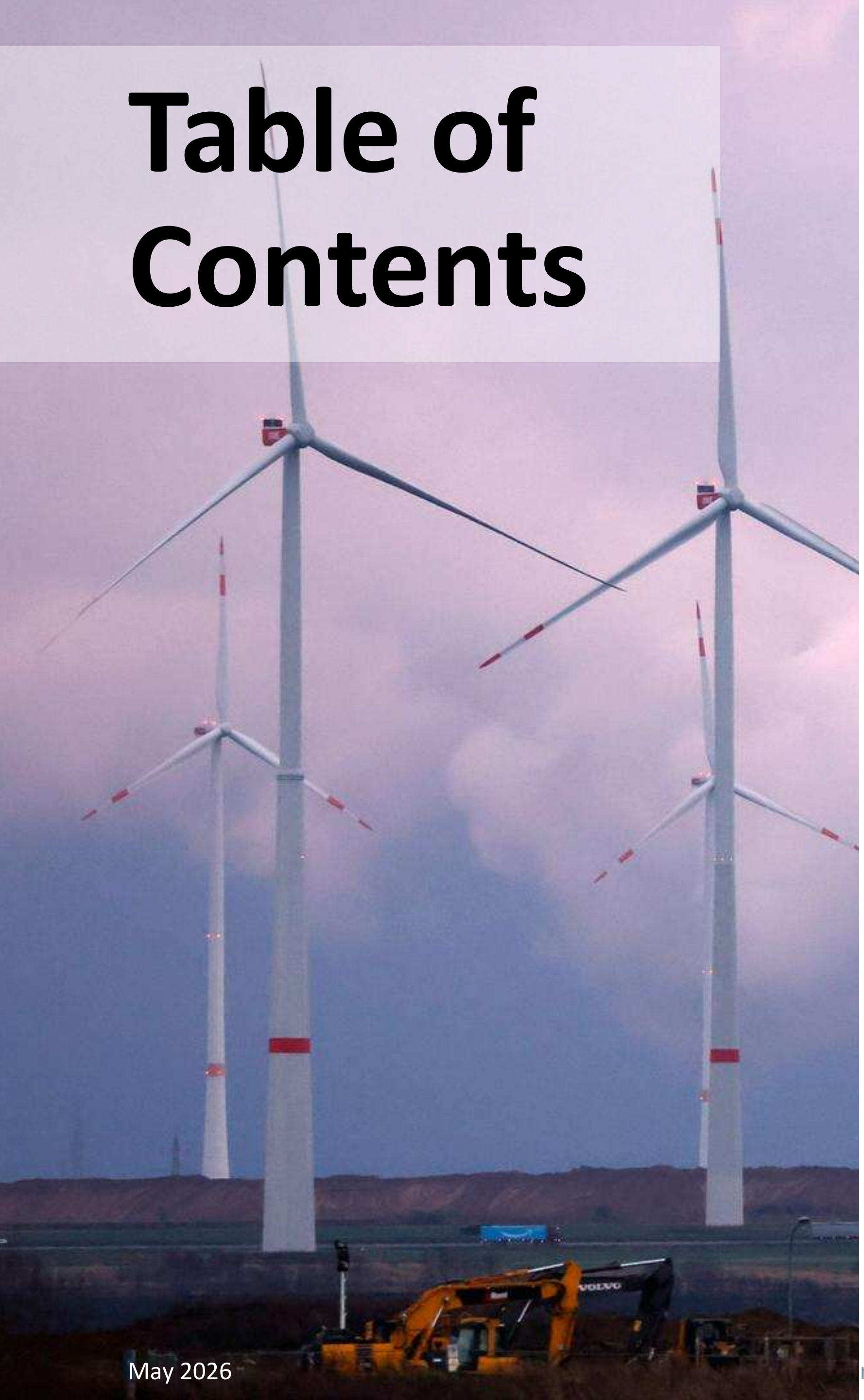
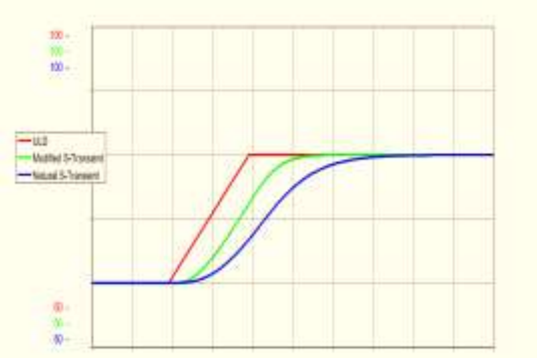
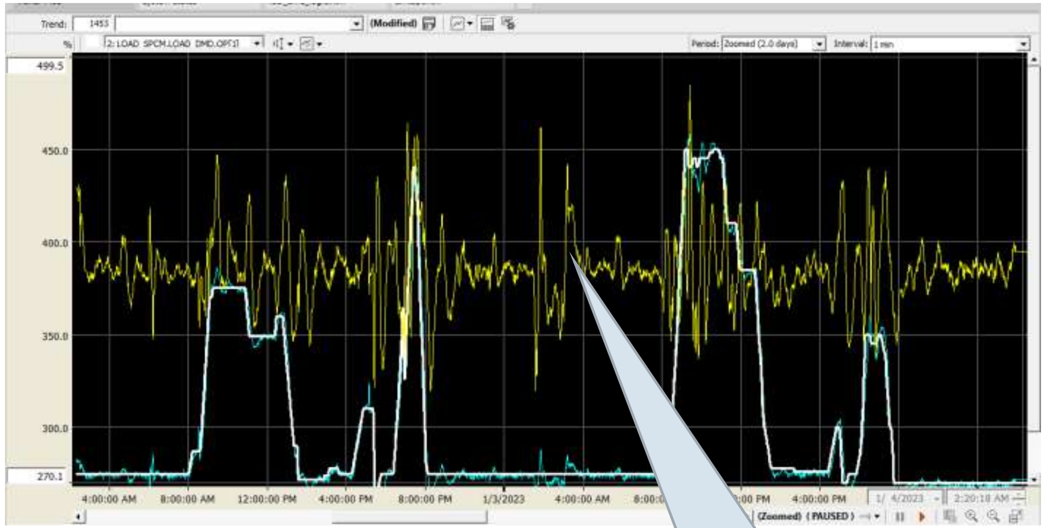


Table of Contents

Results for Load Ramp - 500MW Plant in West India

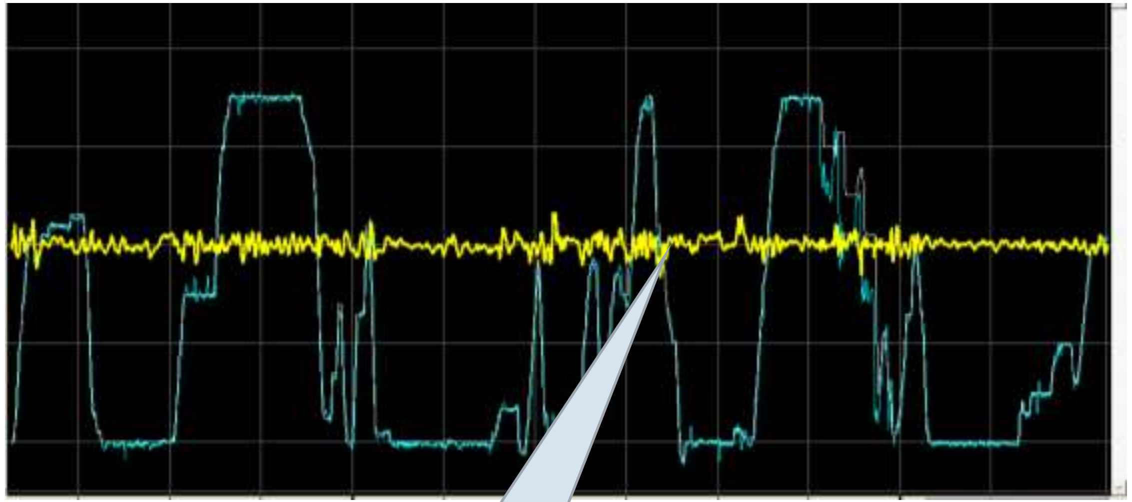


BEFORE



HIGH VARIATIONS IN BOILER MASTER DURING RAMPS

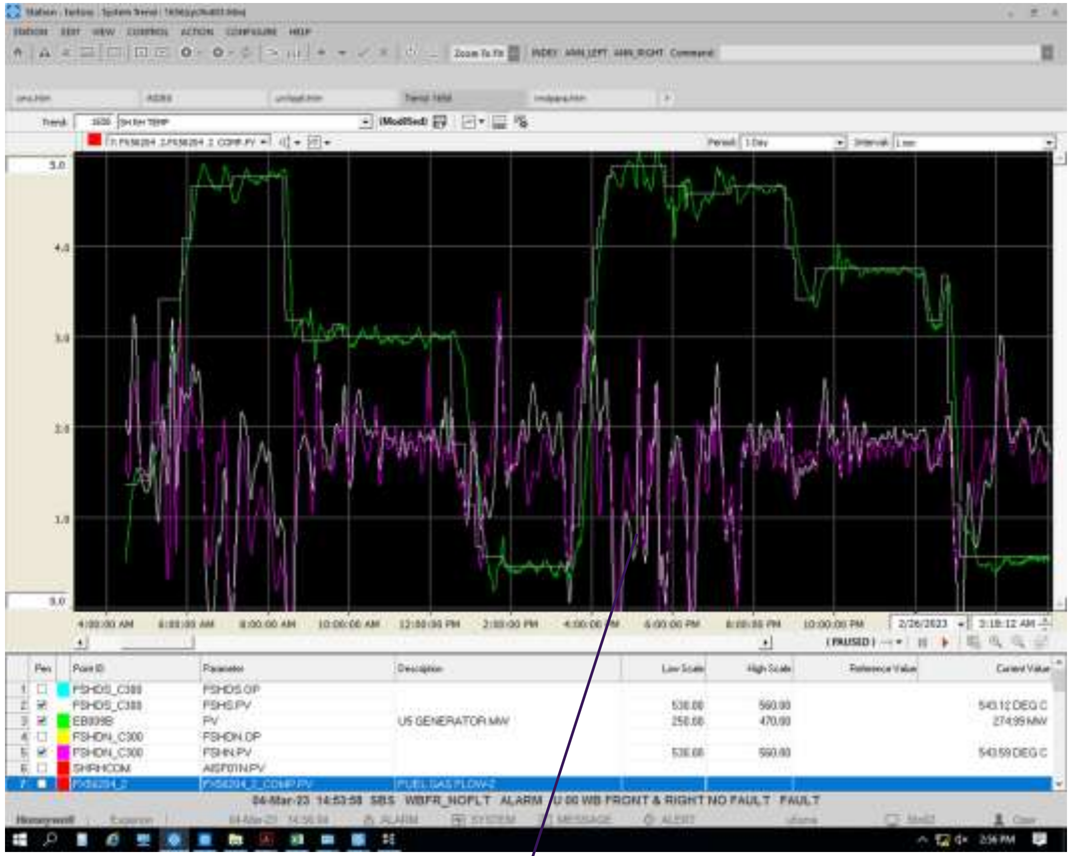
AFTER



LESS VARIATIONS IN BOILER MASTER DURING RAMPS

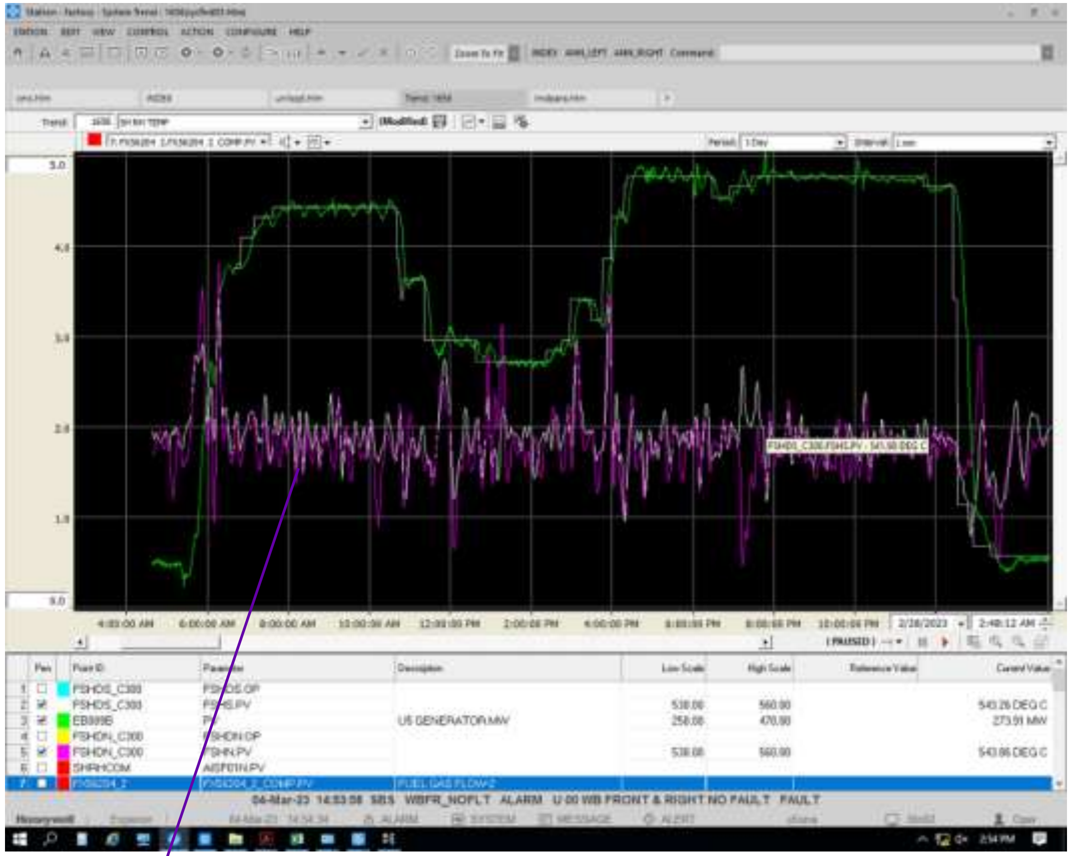
Results for Temperature Optimizer - 500MW Plant in West India

RESPONSE OF STEAM TEMPERATURE ON LOAD RAMP(BEFORE)



HIGHER TEMP VARIATION ON LOAD RAMP

RESPONSE OF STEAM TEMPERATURE ON LOAD RAMP(AFTER)



LOWER TEMP VARIATION ON LOAD RAMP

Summary or results – 500 MW Plant West India

Process Parameter	Status before Project Execution	Target	Achievements
Load Ramp	5 MW/Min	7 MW/Min	8.475 MW/Min
Deviation of SH Temp	+/- 15 Deg C	Steady State:+/- 7 Deg C	Steady State: Max +/- 1.8 Deg C(SD)
		Transient State:+/- 12.5 Deg C	Transient State: +/- 2.75 Deg C(SD)
Deviation of RH Temp	+/- 25 Deg C	Steady State:+/- 9 Deg C	Steady State: Max +/- 1.8 Deg C(SD)
		Transient State:+/- 12.5 Deg C	Transient State: +/- 4.75 Deg C(SD)

Summary or results – 500 MW NorthIndia

Process Parameter	Status before Project Execution	Achievements
Load Ramp	1.9 %	3.6 %
SH Temp dev	Steady State: Max +/- 5 K	Steady State: Max +/- 3 K
	Ramp +/- (12 – 15) K	Ramp +/- 8 K
Technical Min Load	55 %	40 %
Condensate Throttling	7% increase in load in 20 seconds * 5% from ST CV throttling & 2 % from Condensate throttling	

Results- Combustion Optimizer– 500 MW in South India

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IMPROVEMENT IN THE HEAT RATE DUE TO APC COMBUSTION OPTIMIZATION ,STEAM TEMP OPT.& UNIT CONTROL

APC OFF					APC ON					Heat Rate Co-officient (A*)		Calculation	
Parameters	SP	MAX	MIN	Avg. Values	Parameters	SP	MAX	MIN	Avg. Values				
Super Heater LHS temperature	547	537.446533	516.275024	537.0322944	Super Heater LHS temperature	547	551.499939	529.962158					
Super Heater RHS temperature	547	559.945679	539.163208		Super Heater RHS temperature	547	553.262268	537.24054	542.65	A1	-0.029	5.617706	-0.16
RH Heater LHS temperature	572	553.102112	543.878174	547.0299851	RH Heater LHS temperature	572	566.21698	552.209473					
RH Heater RHS temperature	572	550.241089	541.039978		RH Heater RHS temperature	572	562.875366	550.10376	556.78	A2	-0.026	9.750015	-0.25
Avg. Super Heater Spray Flow				0.202999099	Avg. Super Heater Spray Flow				0.944	A3	0.025	0.741001	0.02
Avg. Rh Heater Spray Flow				0.014377641	Avg. Rh Heater Spray Flow				0.0254	A4	0.22	0.011022	0.00
Avg O2 %	3.3	3.62297	2.677688	3.273	Avg O2 %	3.3	3.002701	2.079925	2.59830066	A5	0.25	-0.6747	-0.17
Avg. FLueGas Temp. AH Outlet				129.063235	Avg. FLueGas Temp. AH Outlet				122.53	A6	0.05	-6.53323	-0.33
Unburnt C% In Fly Ash				1.6	Unburnt C% In Fly Ash				1.13	A7	0.4	-0.47	-0.19
Unburnt C% In Bottom Ash				1.96	Unburnt C% In Bottom Ash				2.1	A8	0.1	0.14	0.01
										Total Heat Rate			-1.06
Remarks:-					Remarks:-								
Mill Combination	MILL- B,C,D,E,F,G,J				Mill Combination	MILL- B,C,D,E,F,G,J							
Load range	500 MW				Load range	500 MW							
Date	Wed, March 23, 2022				Date	Wed, March 23, 2022							
Time	11.45 AM TO 2.45 PM				Time	04.30 PM TO 7.30 PM							

Table of Contents

Dispatch Optimization - Working Principle

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1 Data ingestion

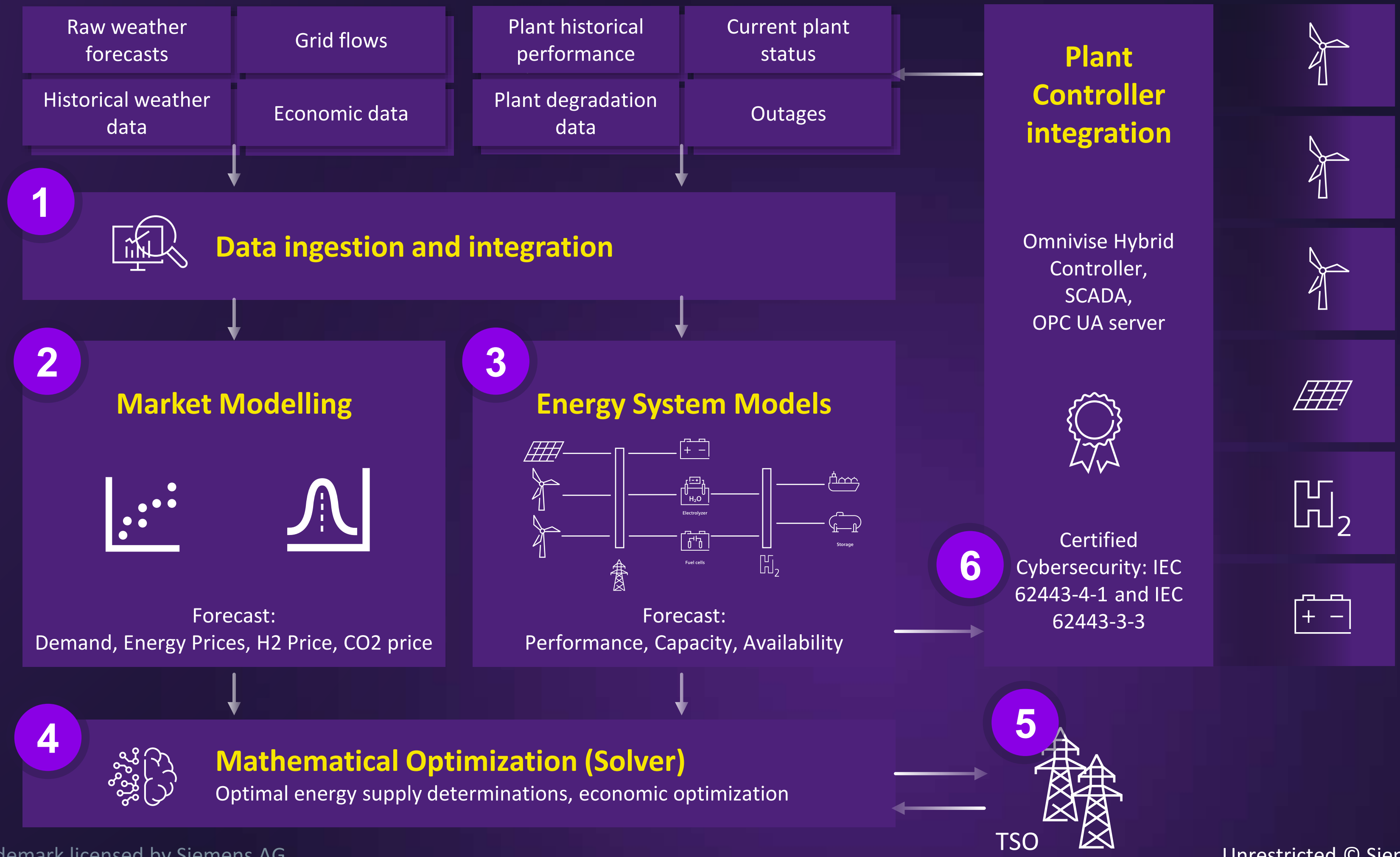
2 Market forecasts

3 Energy system

4 Economic optimization of production

5 Send bids and receive instructions

6 Setpoints to controller



Thank you!

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