

International seminar on AI applications in Power Sector

Organised by Steag Energy Services India Pvt Ltd

In association with

CEA, NTPC Limited, Grid India, ISA, GIZ and DigiSILENT

Applications of AI & Digital twin in Flexibilization & Asset
Management in Thermal Power Plants

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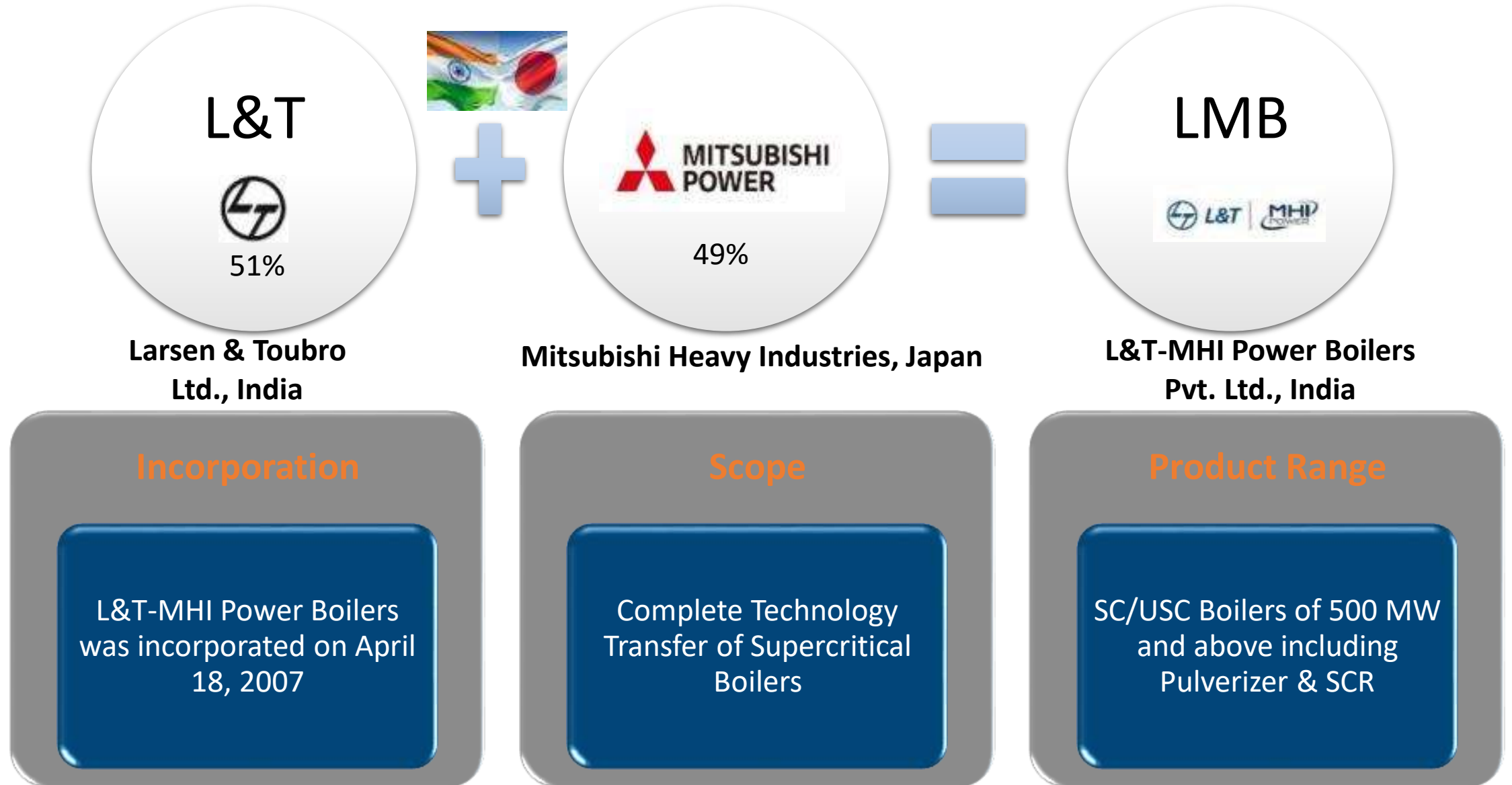


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4	Digital assets monitoring – LMB experience
5	Concept of Digital twin and applications in power plants



About L&T - MHI Power Boilers Private Limited

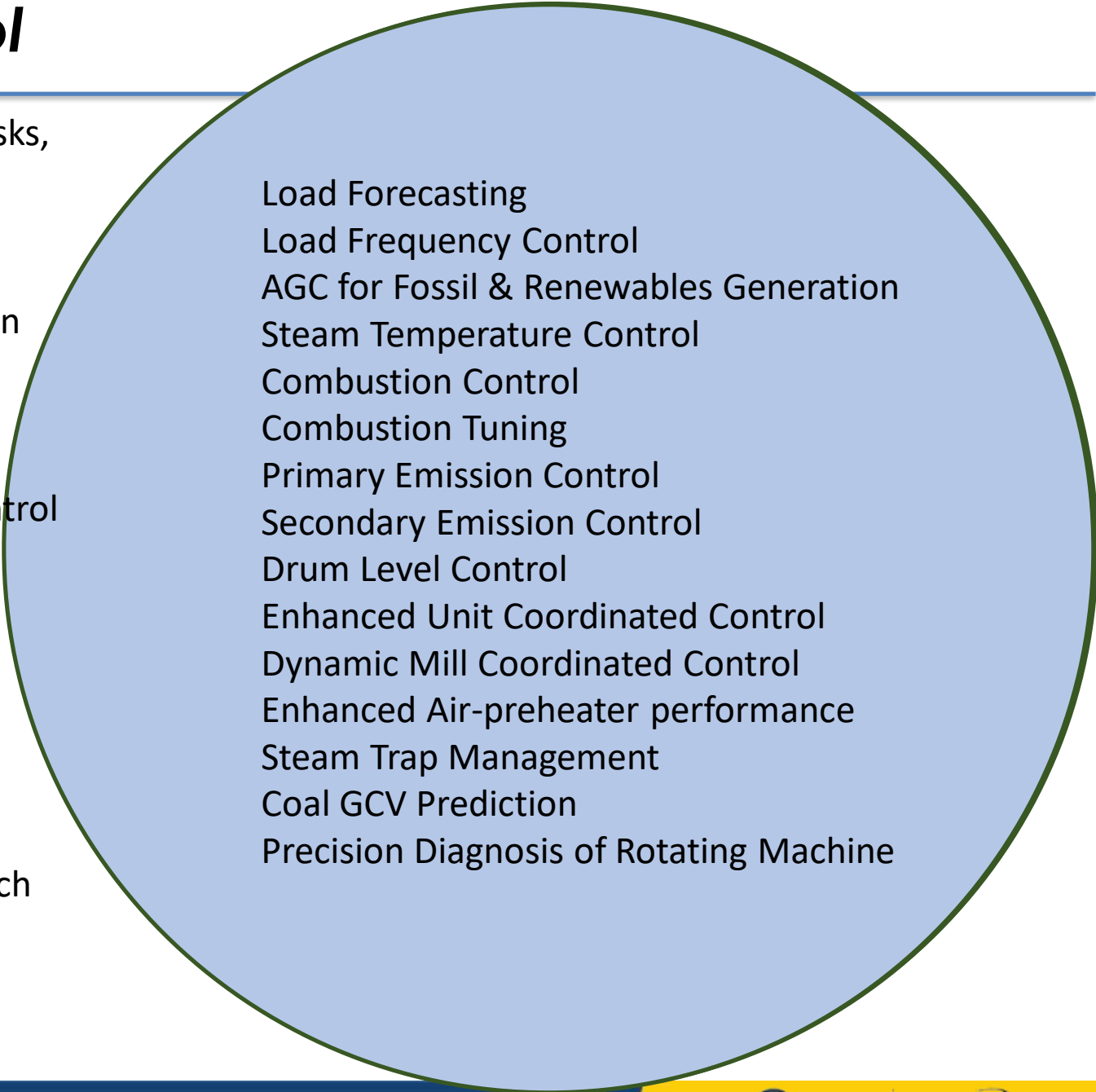


1.0 Key Challenges for Thermal Power in India

- **Significant changes in generation resource mix over the next 25 years**
 - More available capacity than required
 - Prioritization of intermittent renewables & deepening penetration of renewable power generators
 - Thermal Power still required to complete demand as India is balancing the Grid with Coal
- **CEA rules & Energy Markets force existing power plants to work more flexibly**
 - Increased cycling operation of fossil energy power plants
 - Higher ramp rate
 - 40% low load operation
 - Negative impacts of load cycling
 - Thermal and mechanical stresses
 - Equipment health and life expectancy
 - Plant downtime and O&M costs
 - Performance, efficiency, and profitability
 - Environmental emissions
- **Bringing a fierce competition to deliver electricity to the grid**

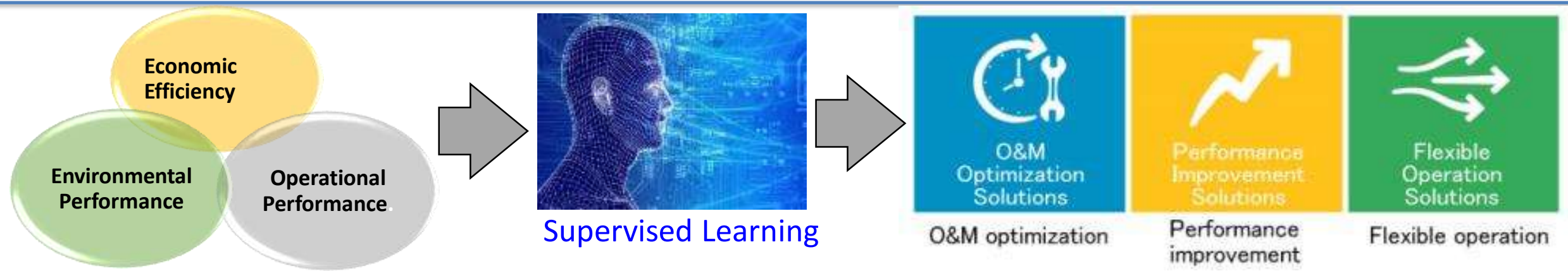
2.0 AI & Expert Process Control

- Pure automation excels at handling routine, repetitive tasks, yet it lacks the ability to independently make decisions.
- Artificial Intelligence, with its self-learning capabilities, transforms into a decisive force, actively emulating human cognitive processes to autonomously address challenges without human involvement.
- This is achieved through a combination of rule-based control systems, ML, deep learning, natural language processing (NLP), and Robotic Process automation (RPA).
- The integration of software-driven mechanisms not only enhances operational efficiencies but also reshapes the company's strategic approach and cultural mindset.
- To ensure seamless adaptation, a comprehensive approach includes upskilling and reskilling of personnel, process refinement, and strategic technology deployment.



Load Forecasting
Load Frequency Control
AGC for Fossil & Renewables Generation
Steam Temperature Control
Combustion Control
Combustion Tuning
Primary Emission Control
Secondary Emission Control
Drum Level Control
Enhanced Unit Coordinated Control
Dynamic Mill Coordinated Control
Enhanced Air-preheater performance
Steam Trap Management
Coal GCV Prediction
Precision Diagnosis of Rotating Machine

Technology Partners for Flexibilization



MHI, Japan (Process, Performance ,Mechanical)

(Burner modification, Combustion Modification, Mill modification, Pressure parts improvement, Boiler AI Combustion Tuning and Unit Control Tuning)



ADEX, Spain (Controller is **Self-Tuning Adaptive Expert Control, ADEX**)

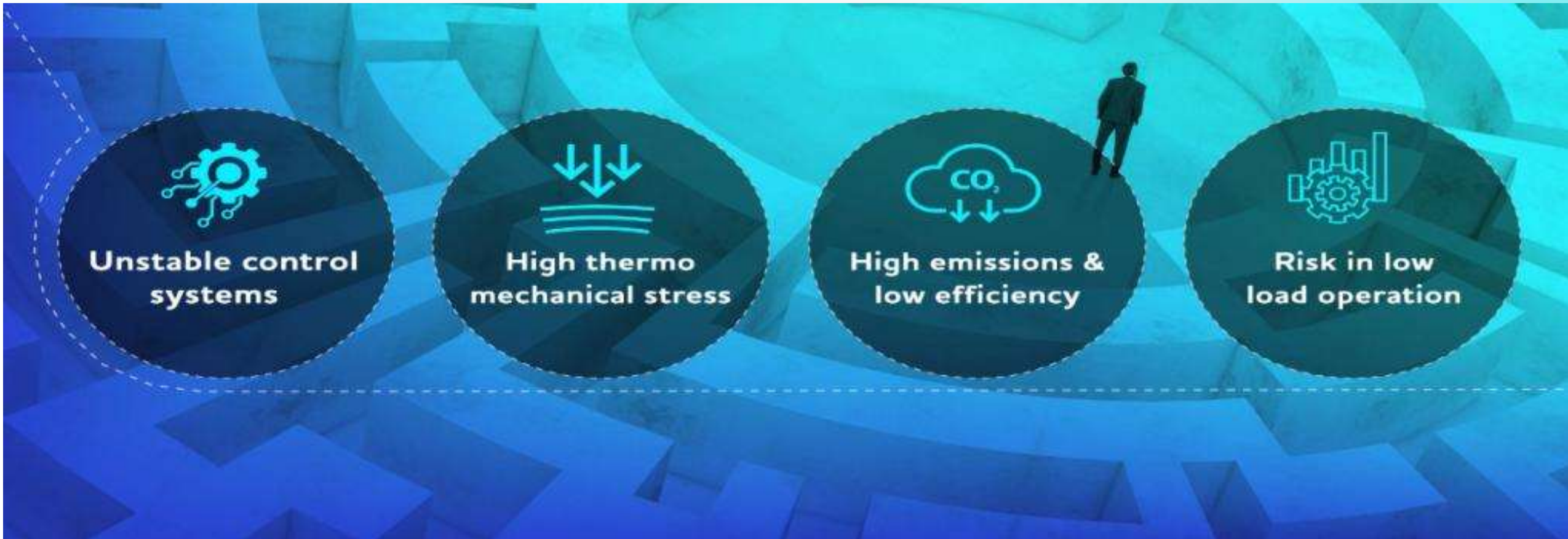
- 150 processes optimized, **internationally**, 80 of them commissioned along 40 Units in power plants collecting **+16GW in Europe**

(Steam Temperature Optimizer, Drum Level Optimizer, Combustion Optimizer)



3.0 Self Tuning Adaptive Process Control

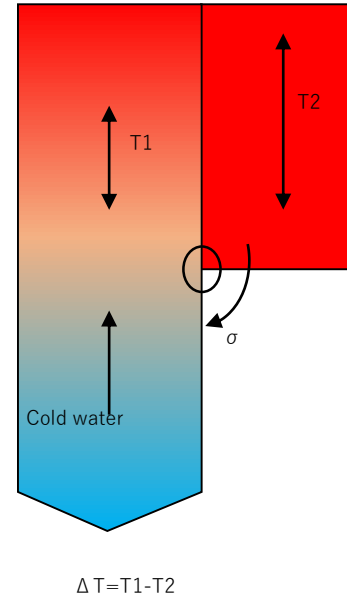
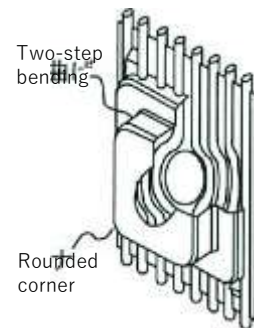
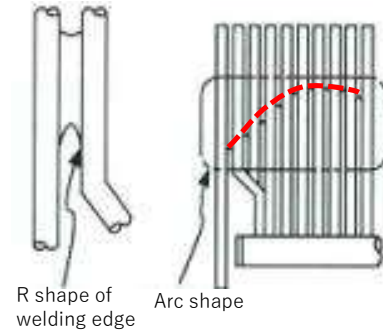
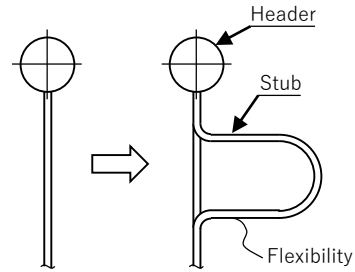
The Problem



Current Options to address those Challenges

- HW retrofits

EXPENSIVE



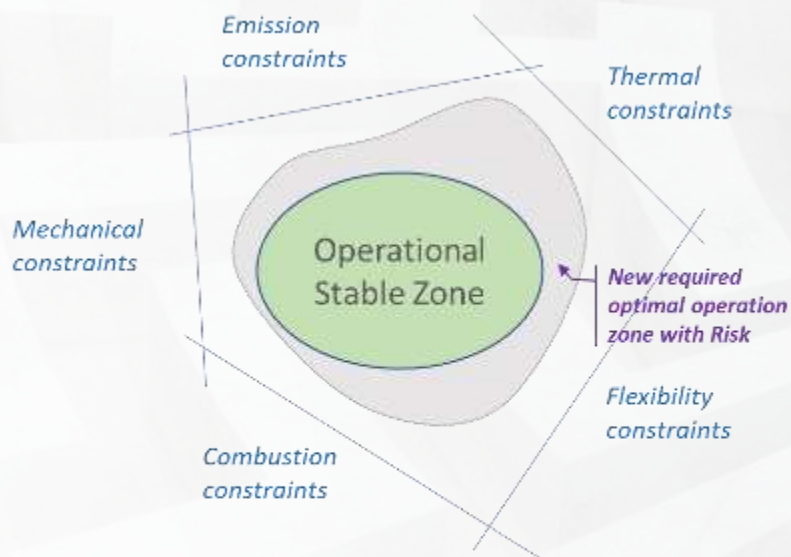
SW Control Systems Upgrades

CONSTRAINED

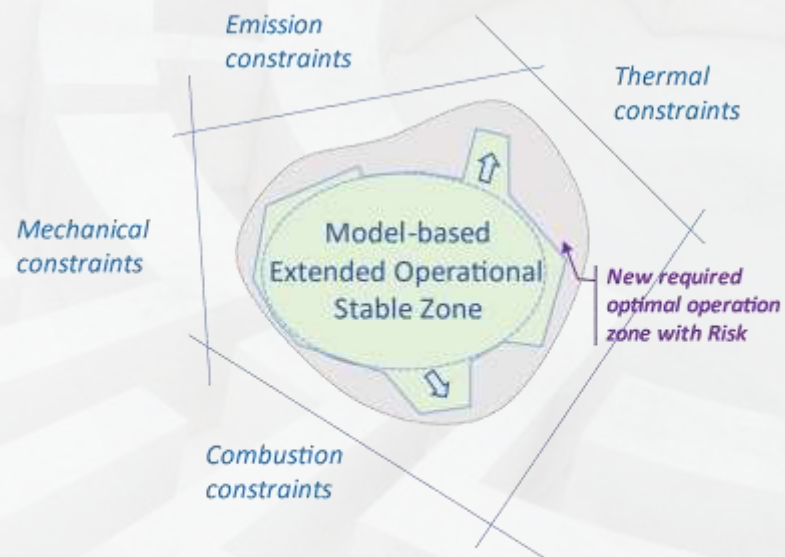


New operation points

ADEX enables optimal operation **WITHOUT** risk



Power plant operation with existing control systems and conventional PID controllers



Power plant operation with APC and conventional PID controllers

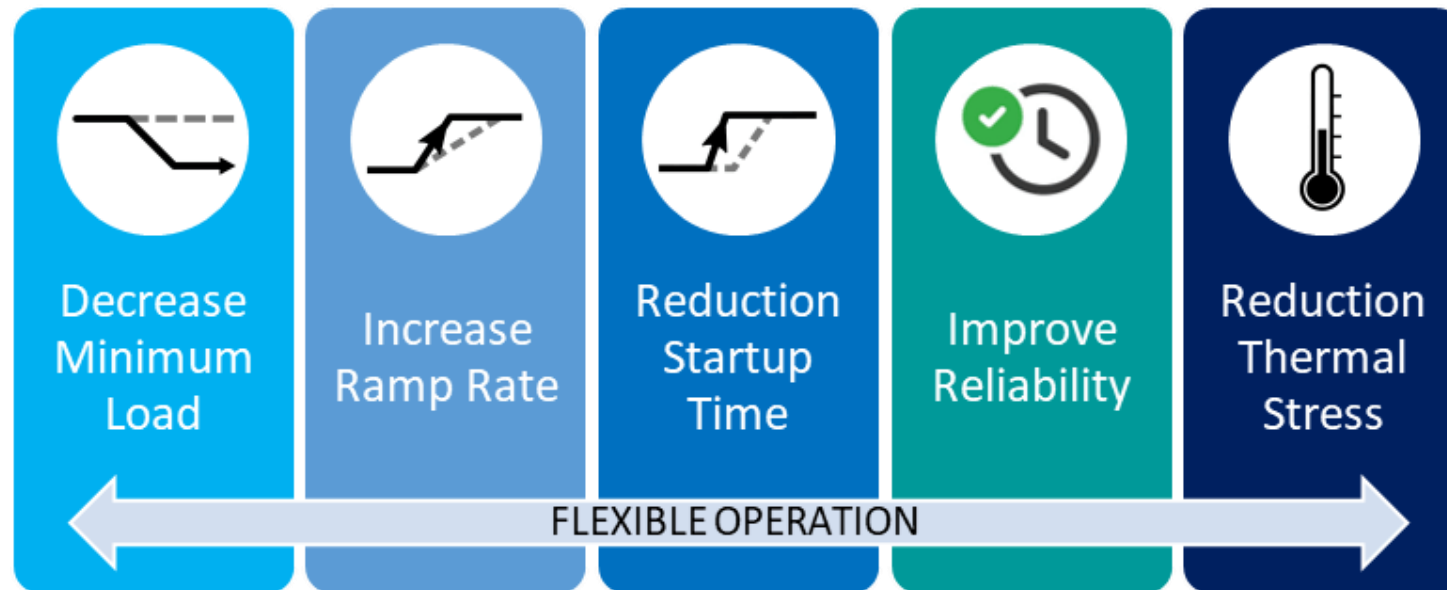


Power plant operation with ADEX

ADEX control **extends the comfort zone**, to where the operation is **safe and stable**, optimizing performance in flexible operations

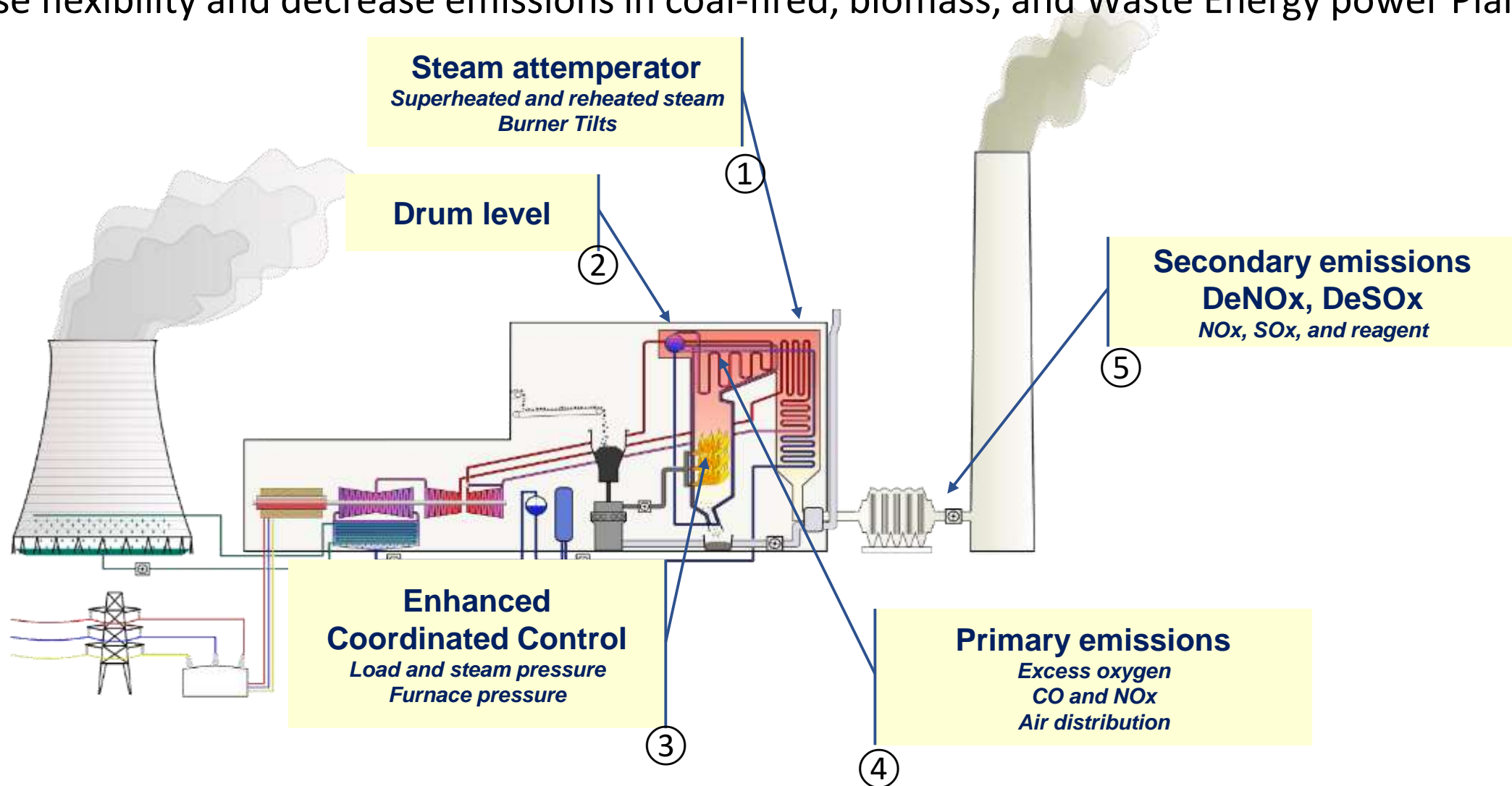
Benefits Of Self Tuning Adaptive AI Control

- A SW **add-on** to the existing control system
- **Self-tuning Artificial Intelligence Platform**
- Integrates **patented ADaptive EXpert Controllers**
- Commissioned **on-premises**



How can this extra performance be achieved?

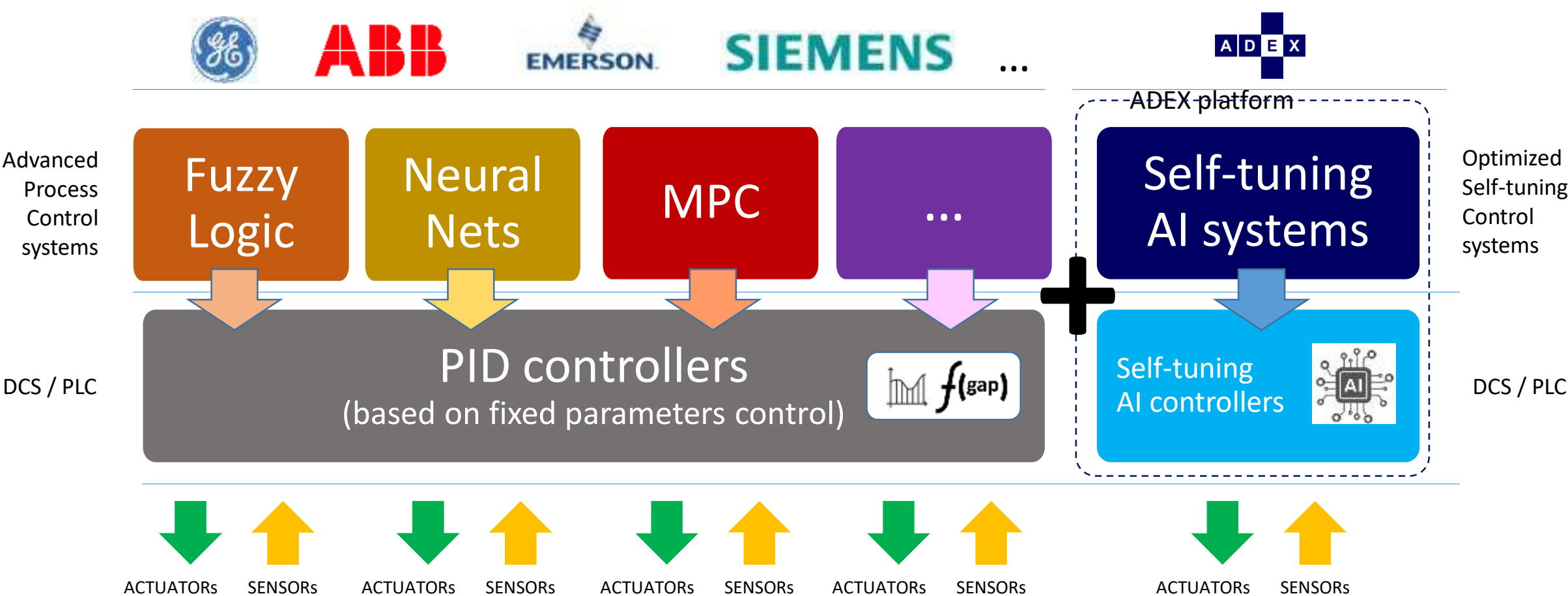
ADEX Technology may be applied to any or all the following processes which improve Thermal Efficiency, increase flexibility and decrease emissions in coal-fired, biomass, and Waste Energy power Plants



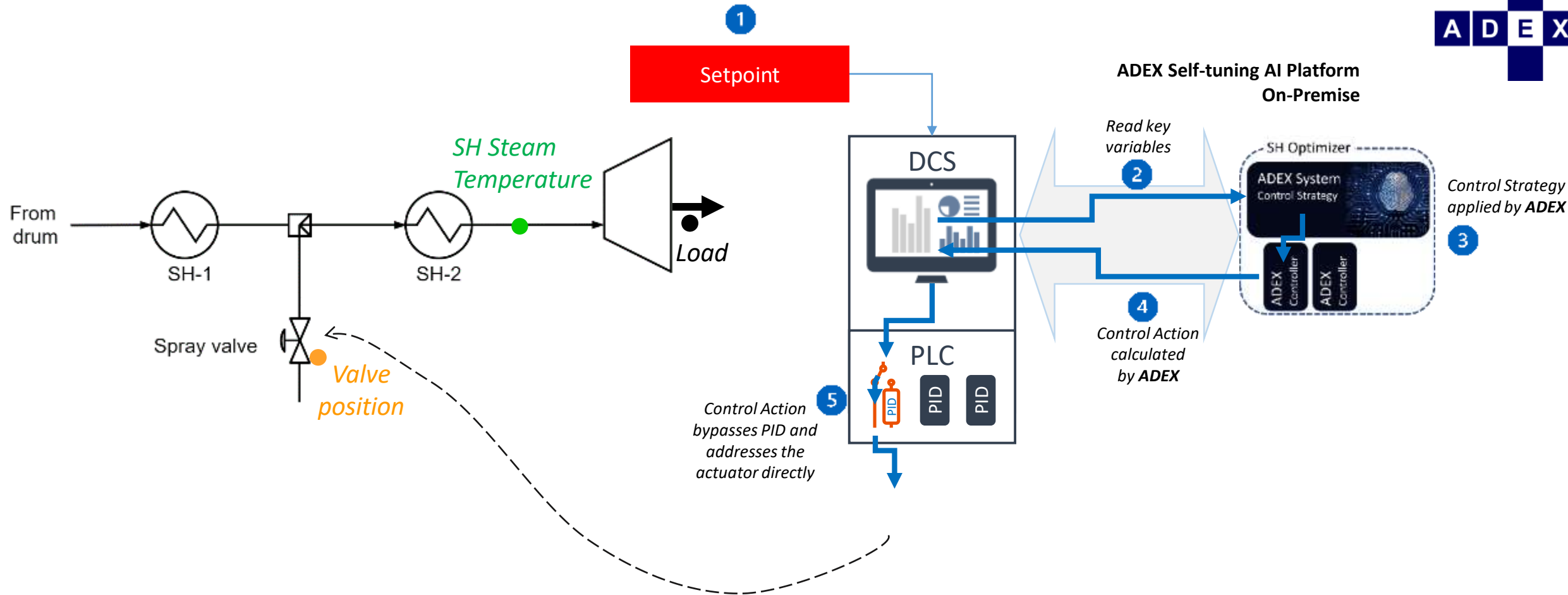
How ADEX controller works



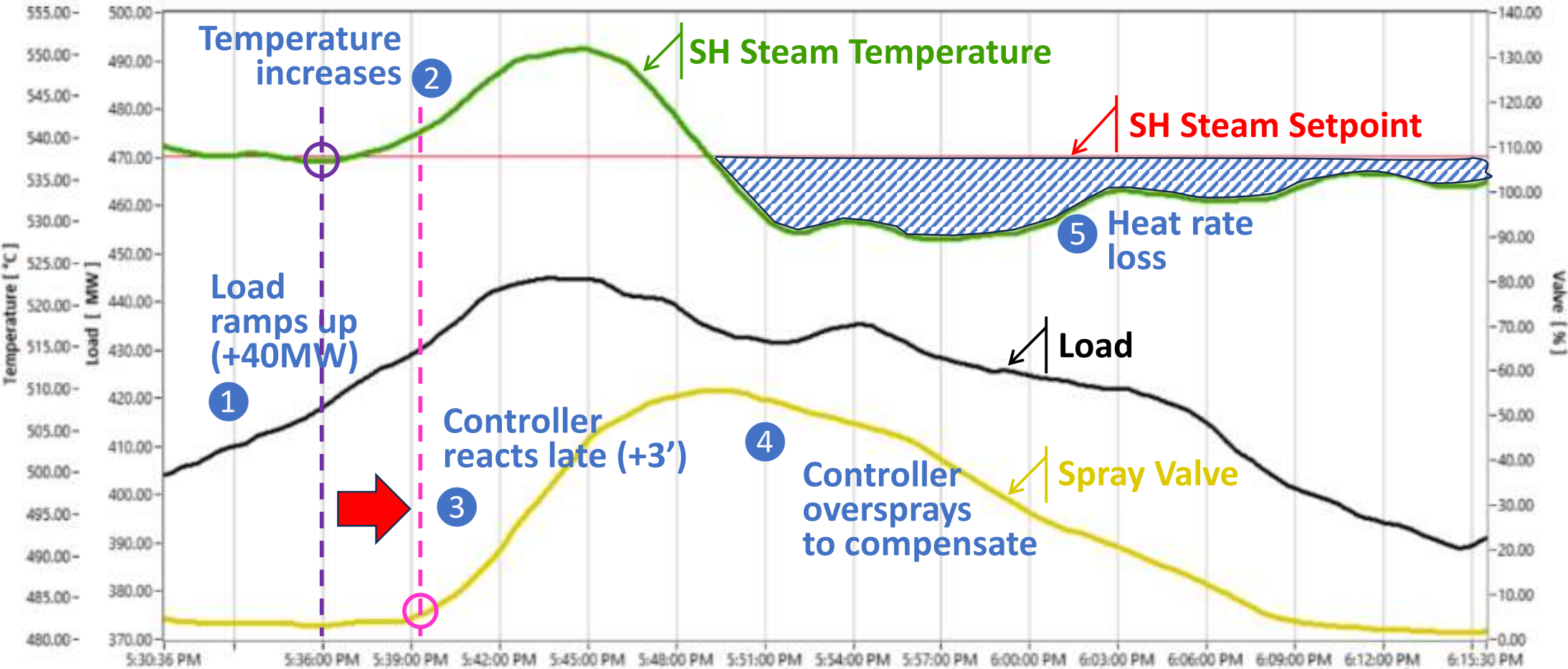
SW Add-on to the existing control system



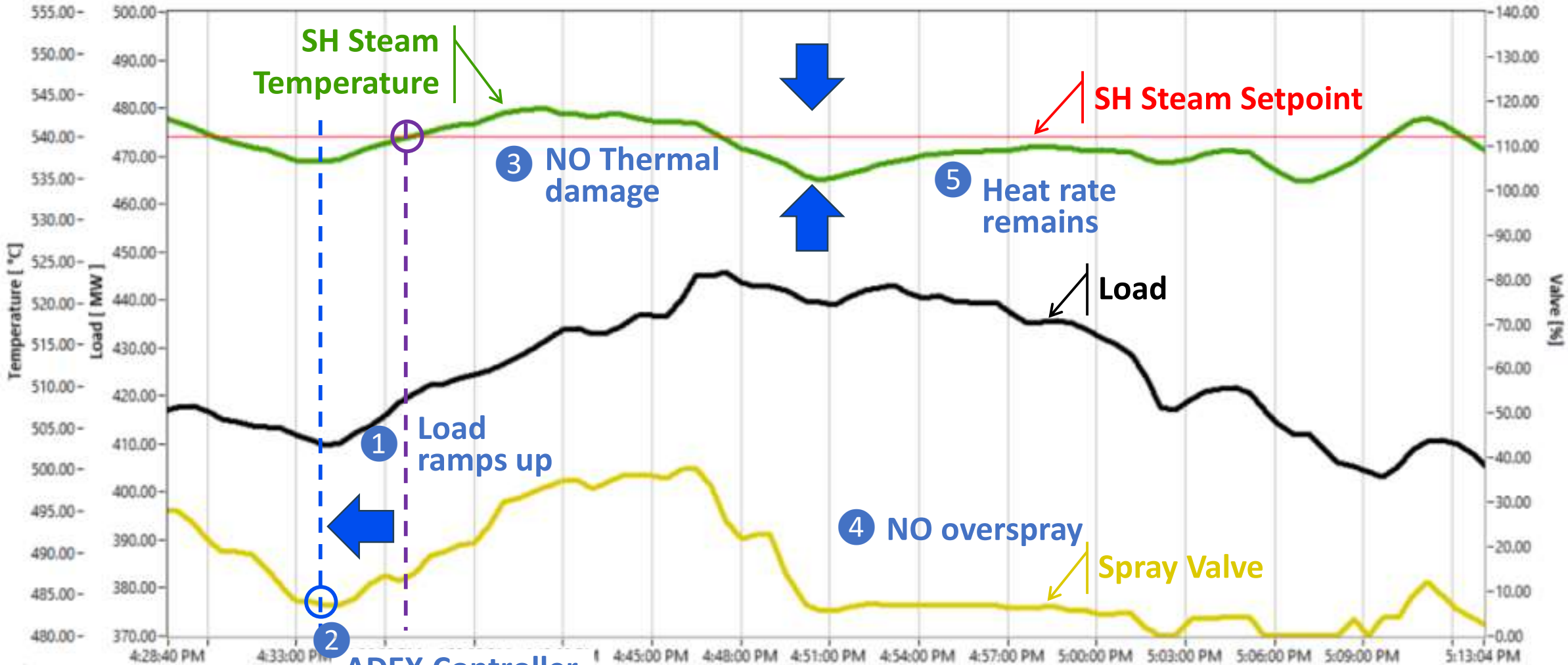
How ADEX control system works



How conventional control systems work



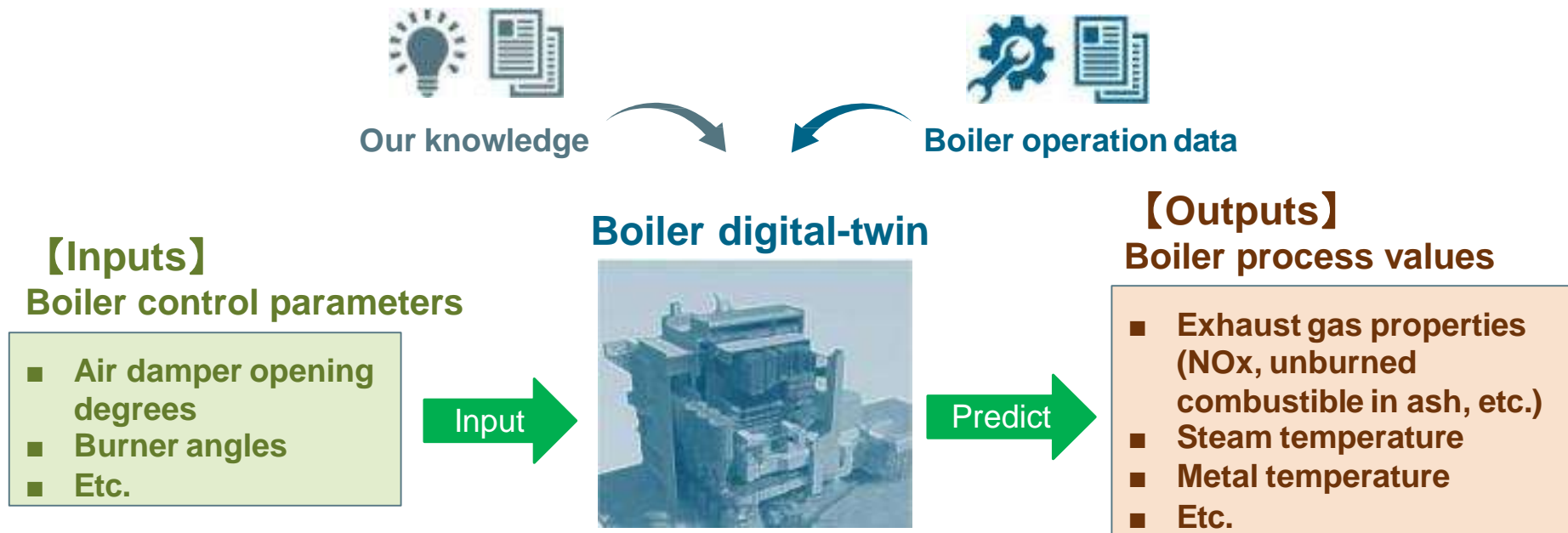
How ADEX controller works



ADEX Controller
anticipates

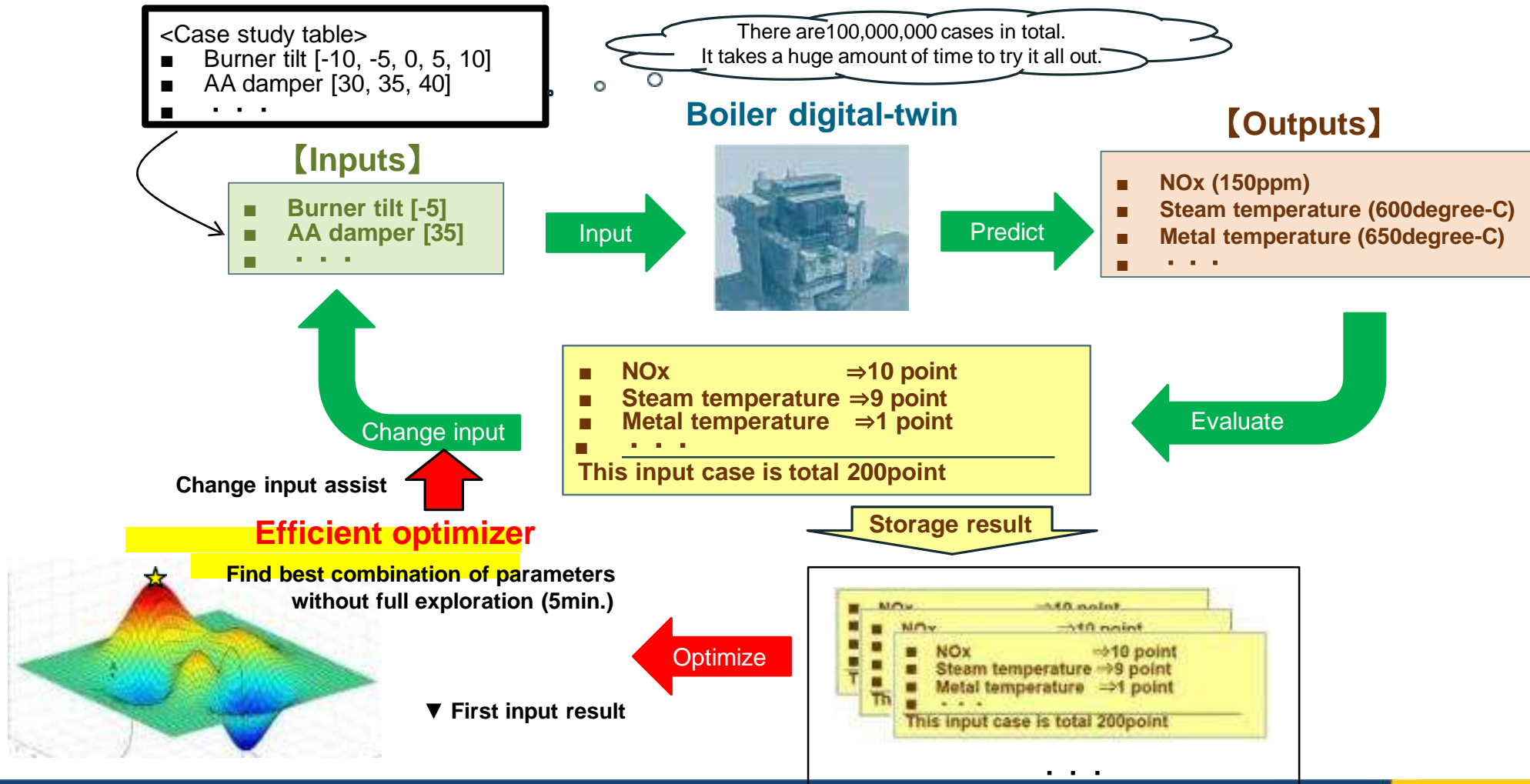
Boiler AI Boiler tuning

- Boiler tuning is optimizing boiler process values with boiler control parameters, and it has long relied on the experiences and expertise of manufacturers' skilled engineers. Instead of them, MHI developed “Boiler AI Combustion Tuning” using a digital twin technology.
- Boiler digital-twin is a virtual boiler that behaves like a real boiler in a digital space by learning boiler operation data and our knowledge, experience of boiler manufacturer. Digital twin enables to predict outputs for various inputs.



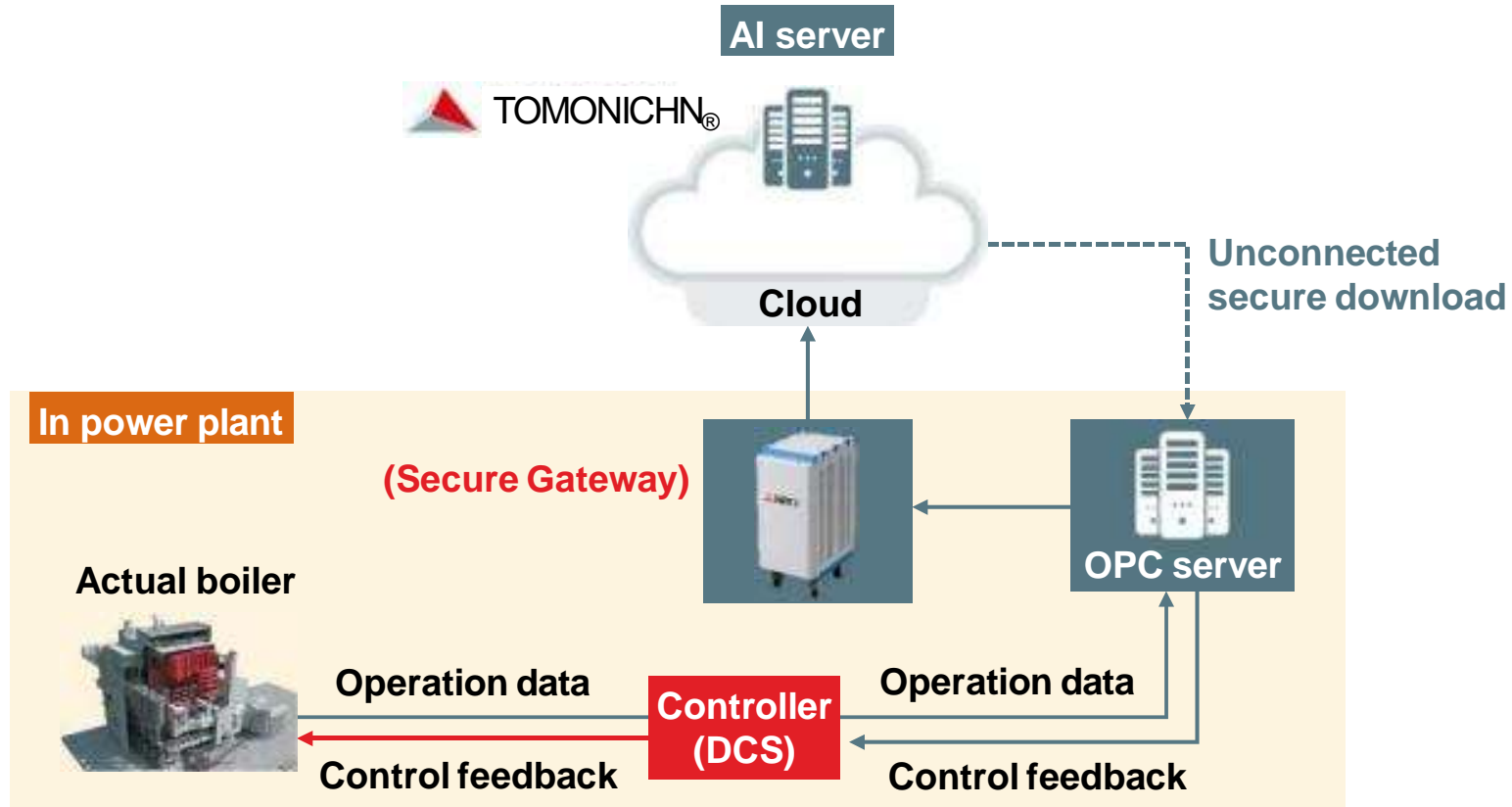
Optimization using Boiler digital-twin

- The digital twin enables the simulation of a boiler with a huge number of combinations of input parameters.
- With efficient optimization program, it is possible to find the best settings based on certain evaluation criteria from a huge number of parameters in a short time.



Boiler AI System overview

- In a system built on our cloud-based / on premises platform “TOMONICHN[®]”, operation data of actual boiler is acquired and analyzed to feed back the best settings.



Asset performance management

Smart inspection

Supports planning of inspection items based on past history and records

Boiler smart search

On-Demand access to Interactive Technical Manuals, Videos, Data Sheets and Documents

Analysis of event log

Analysis of event log to identify anomalies in operation

Water quality assurance

Water quality is continuously and tendency of water quality with guidance and evaluation result is displayed

LMB Digital | Industry 4.0 Adoption

SNAPSHOTS



MOBILITY



TERMINALS



IIOT



CLOUD



ROBOTICS



M2M



**MACHINE
LEARNING**

And many more...

TECHNOLOGIES

*Computed
Radiography*

GPS

*Data Acquisition with
Asset Insight Platform*

*Business Intelligence
Report Server*

*Progressive Web
Applications*

*R, Python and
Jupyter/Azure NB*

*RPA using Automation
Anywhere Ent. Client*

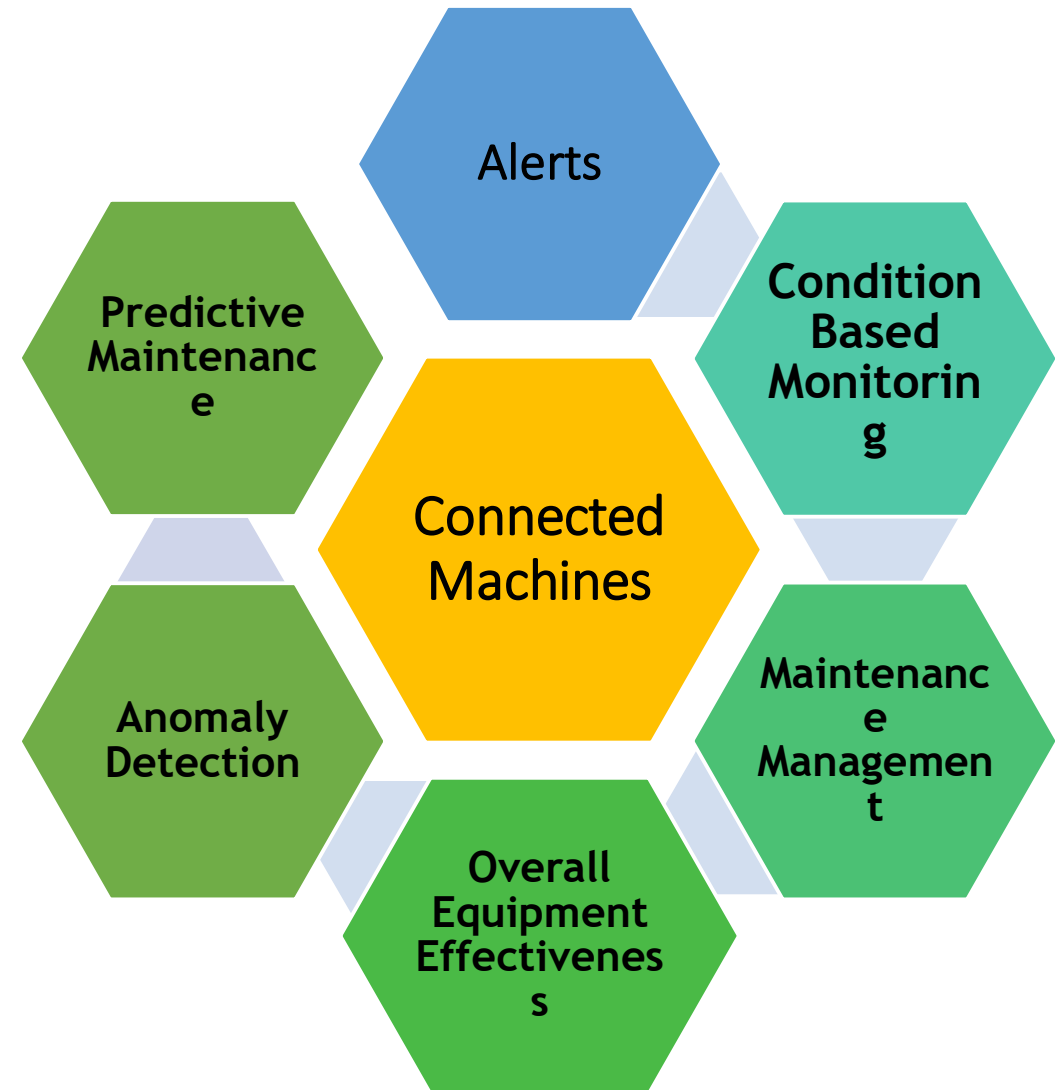
*MS
PowerApps/Automate*

*CAM NX Pro Model to
Manufacturing*

*Custom Developments
/ App.-ERP Integration*

And many more...

Connected Machines



Connected Machines

CONDITION BASED MONITORING



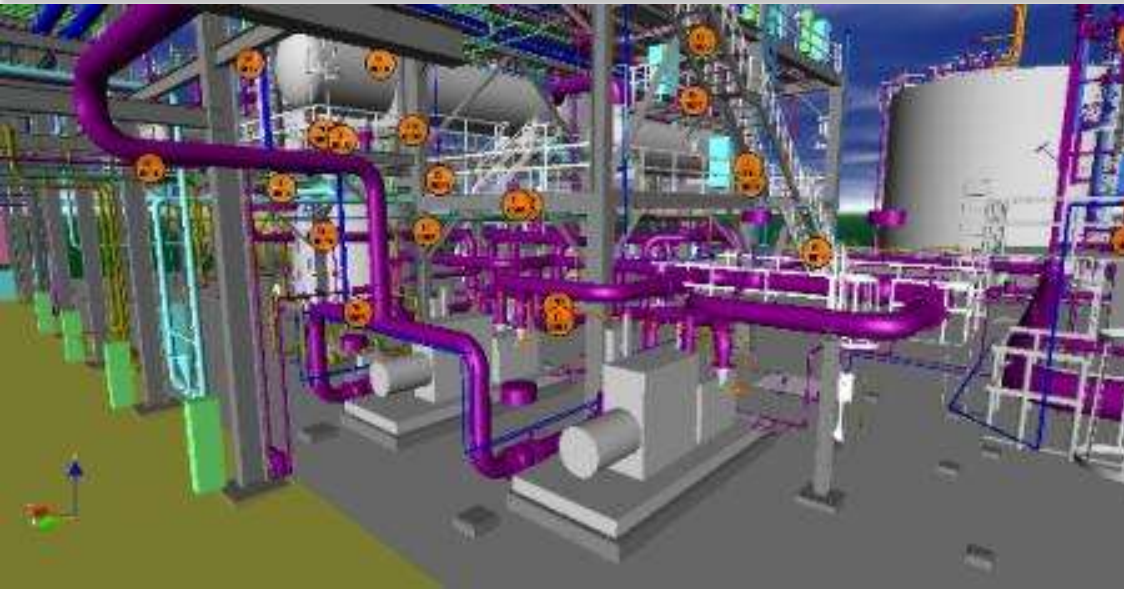
PREDICTIVE MAINTENANCE



DETAILS

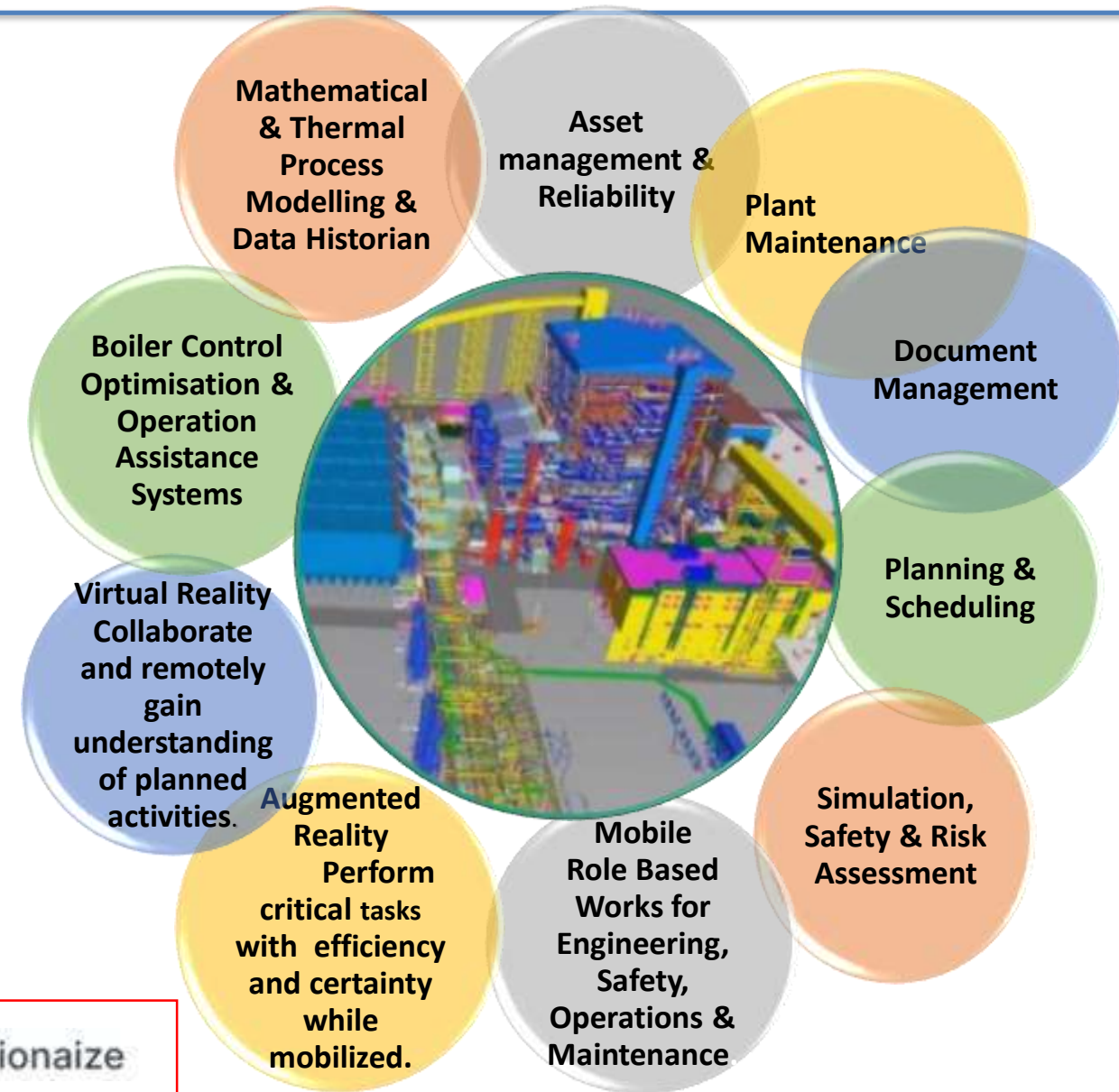
- ✓ CBM OEE Dashboard
- ✓ Anomaly detection
- ✓ Predictive alerts
- ✓ Root Cause Analysis
- ✓ Remaining Useful Life Calculation
- ✓ Reduction of spare inventory

Digital Twin - Integrated Dynamic Simulation and VR Technology



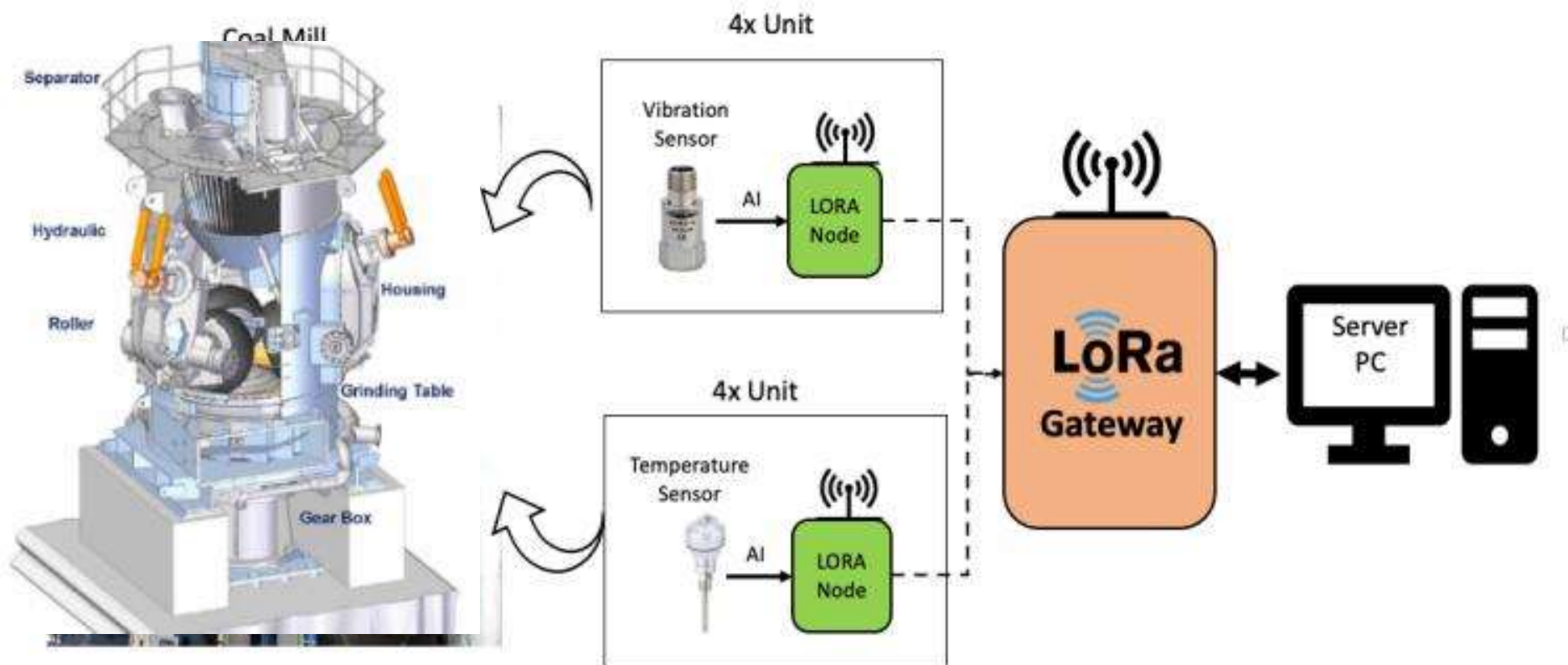
- 3D interactive, immersive virtual reality(VR)
- Dynamic Model-based Sensor Network
- Real-time data connection
- Virtual digital test bed for power plant R&D
- Advanced process control
- Multiple Model Predictive Control /Biomimetic Adaptive Control
- Nonlinear state estimation
- Condition-based monitoring / Fault diagnosis

Courtesy  Visionaize



Digital Twin of Coal Mill

- Generic Mathematical Model using AI & ML for prediction of mill response under varying coal flow/coal characteristic/operating parameters to
- Maintain minimum differential pressure across it
- maintain mill outlet temperature so that the boiler response can be improved under flexible operation

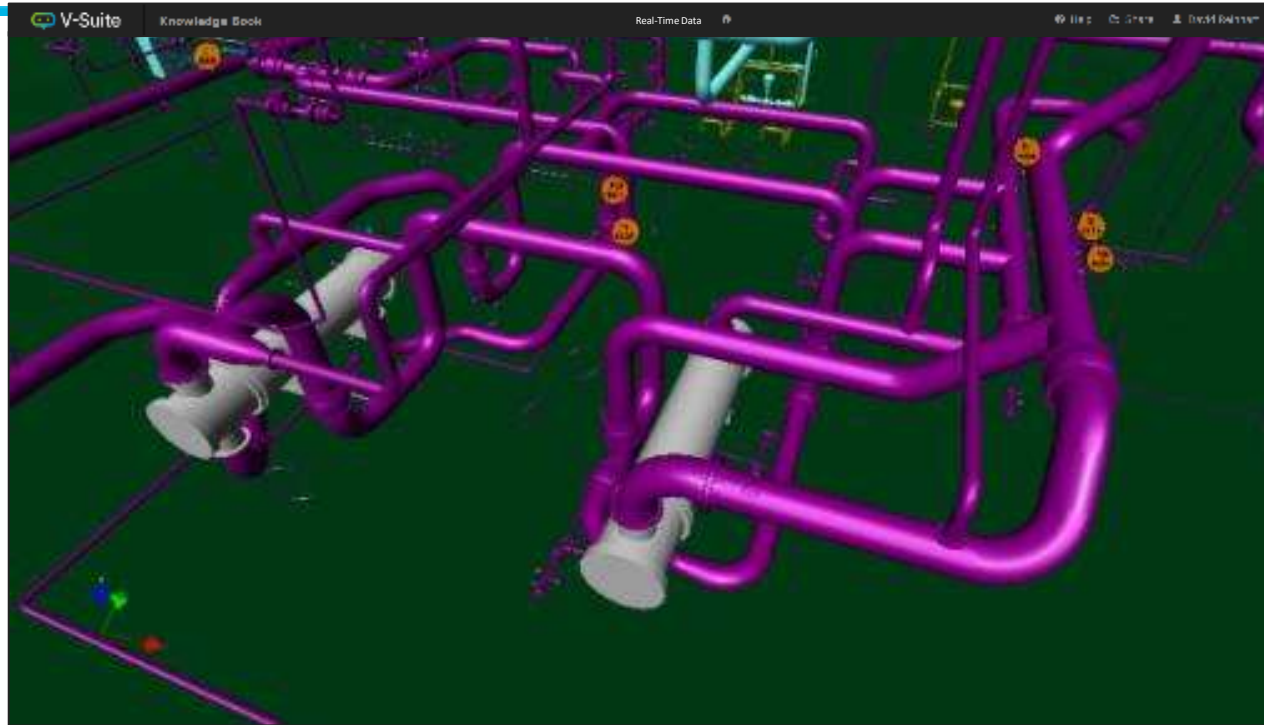


Digital Twin – Real time visualization and monitoring

Operations:

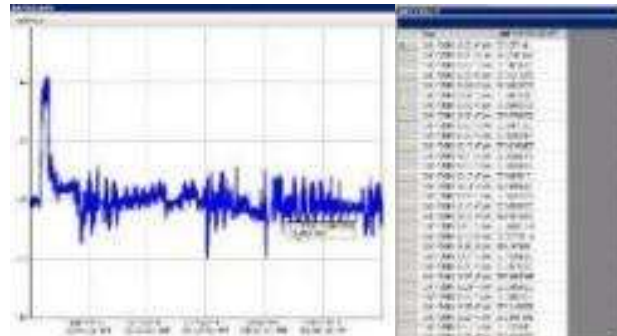
Visualize
Operational
Data

- Flow
- Pressure
- Temperature
- Condition
- IOW Excursion



Valuable insight normally presented
in 2D graphs or dashboards are enhanced with
dynamically activated and data-driven 3D
Knowledge Views.

Courtesy  Visionaize



Digital Twin – Real time visualization and monitoring

Operations: Real-Time & Analytics

- Sensors
- Context & Connectivity
- Condition
- Health
- Risk
- Criticality
- Prediction
- Recommendation



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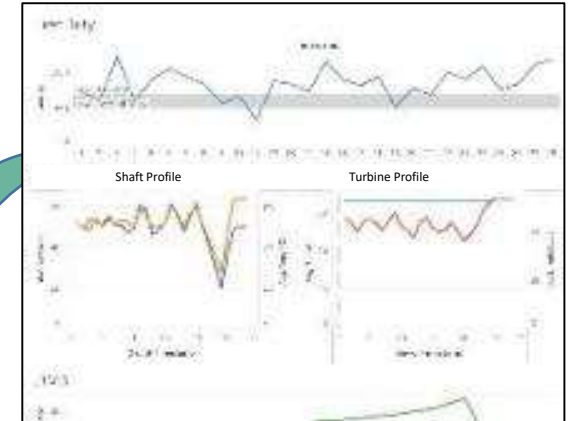
Digital Twin – Real time visualization and monitoring

Visualized online precision diagnosis of large-scale rotator

With the Digital Twin 3D virtual model and analysis results of twin data, the system can remotely display many important and critical asset performance values:

- ✓ State of equipment and component
- ✓ Severity of the problem
- ✓ Description of the fault
- ✓ Processing method

All done in real-time, enabling remote and online diagnosis of equipment, or Recommended Action(s)



Courtesy  Visionaize

Courtesy  Visionaize

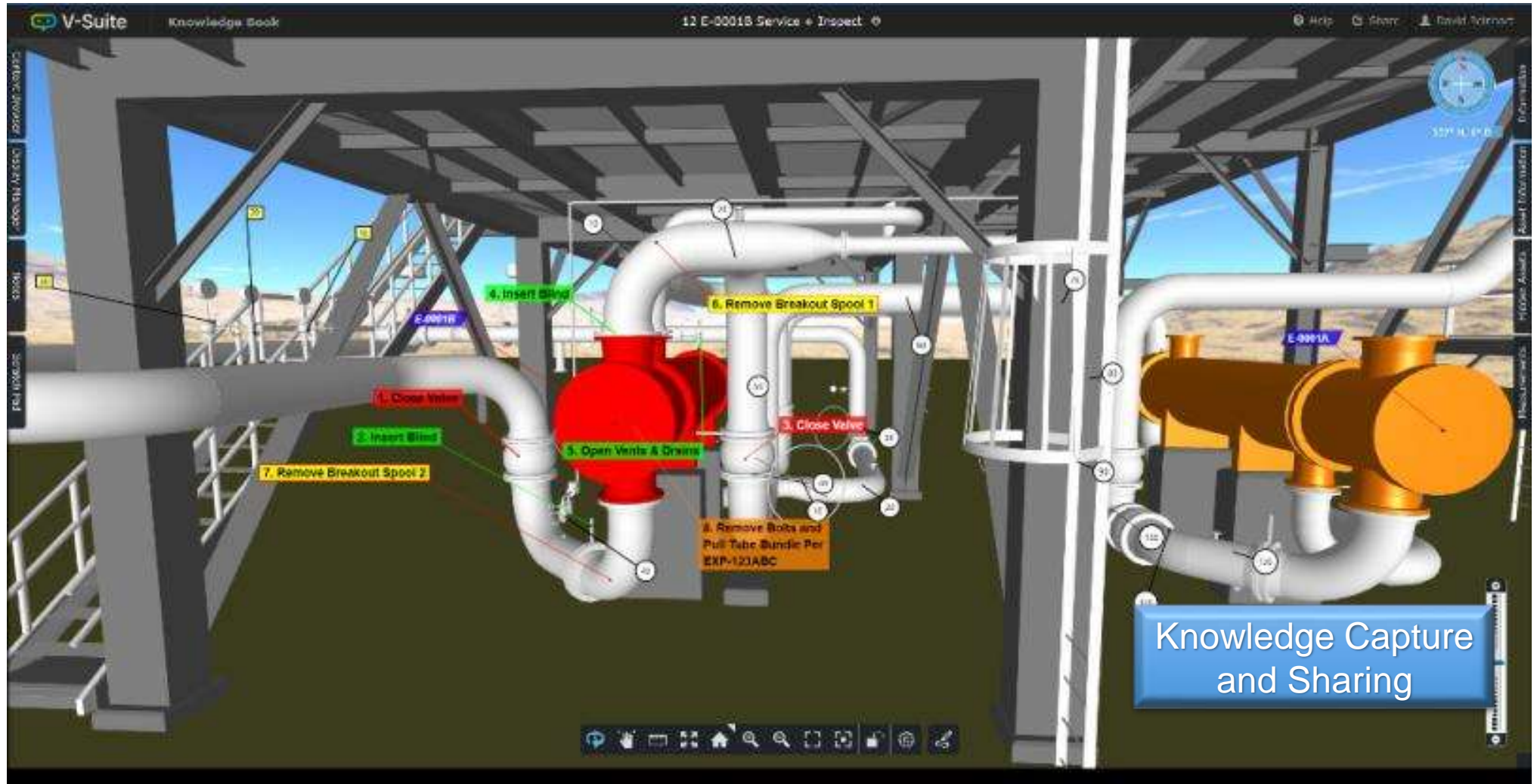
Outage planning and maintenance activities

Outages & Routine Maintenance:

Plan & Visualize activities before mobilizing

Equipment isolation, Lock-out Tag-out, Remove & Replace, Rigging, etc.

- Optimize
- Consolidate
- Collaborate
- Familiarize
- Train
- Analyze



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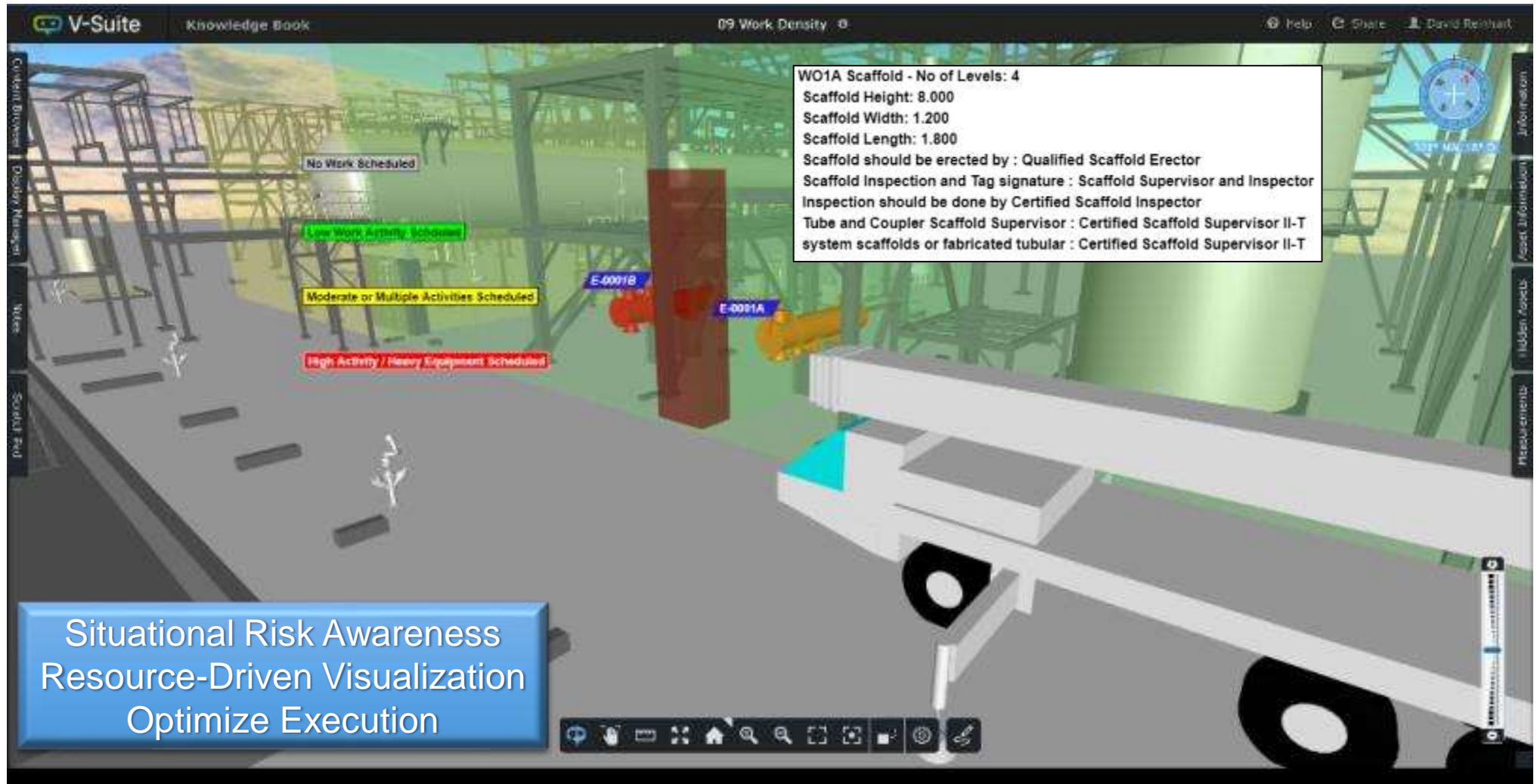
Outage planning and maintenance activities

Outages & Routine Maintenance:

Temporary Assets & Activity Zones

Data & Schedule Driven Display

- Scaffold
- Equipment
- Work Zones
- Craft Density
- Safety Zones
- Hazards
- Scheduled Activity



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Digital Twin in Safety and Security

Problem:

Safety of the facility, its equipment and its occupants is key. This means we need to monitor every access point and every nook and cranny of the site

Solution:

V-Suite taps into all security systems. Access control systems, perimeter alarms and fire, smoke and Carbon Monoxide detection systems and all CCTV camera feeds and gives the managers a single view and ability to control things from any connected device.

Benefits:

- ✓ Situational Awareness and timely response during Emergencies.
- ✓ Orientation and Training for personnel and occupants using V-Suite (VR & AR) on egress routes.

Courtesy  Visionaize



1. Where is the best / safest way out?
 - Plan: Immersive 3D to show people before an emergency event
 - Alert: Phone to 'show me' the safest and most efficient way out during an emergency / event
2. Where are the people during an emergency event? Seen on the 3D

 Visionaize

Thank You



L&T-MHI Power Boilers Private Limited