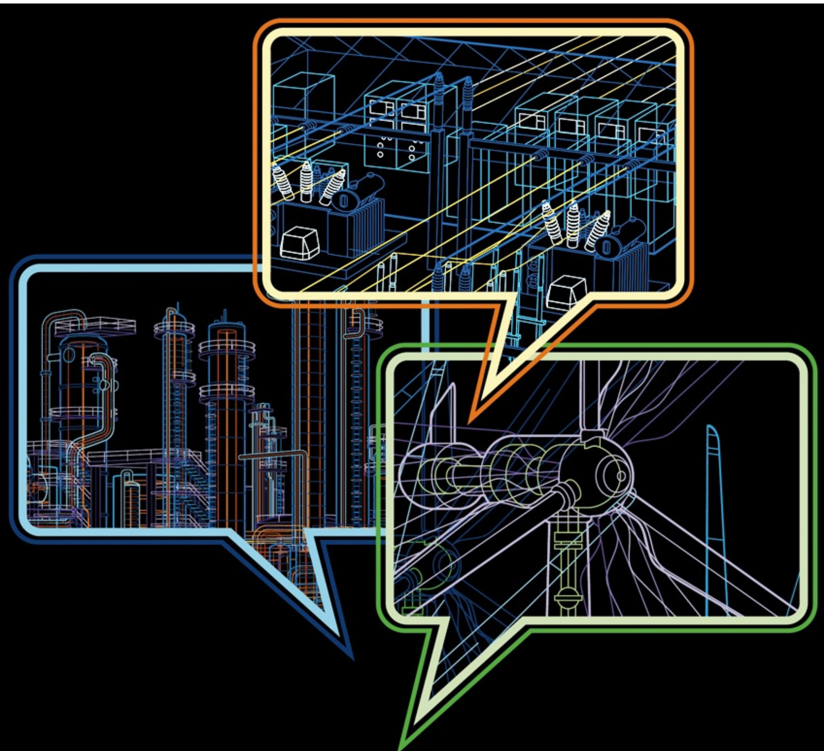


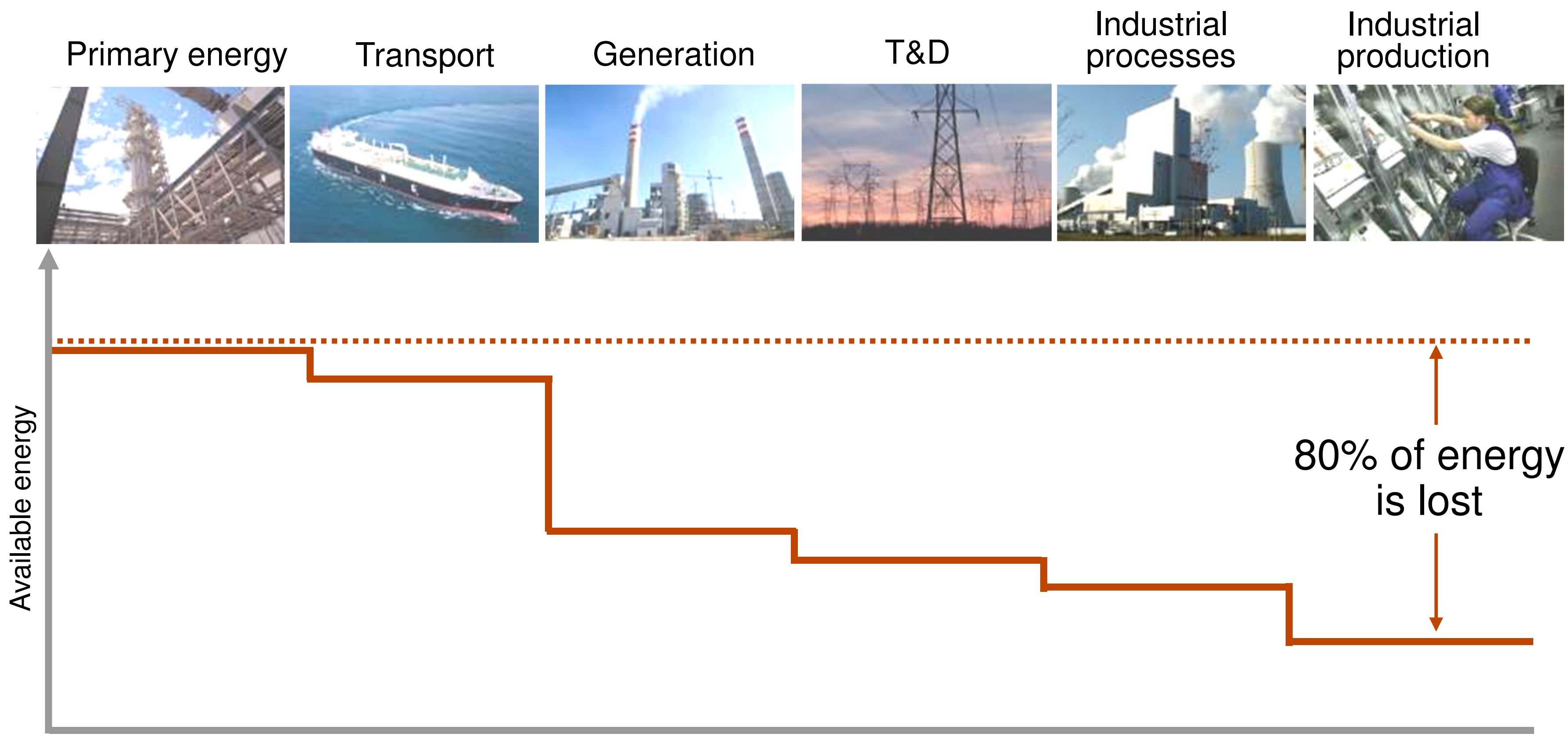
Gerhard Brandt, ABB AG, Mannheim, Germany

Solutions for Performance Monitoring, Diagnosis and Optimization of Power Plants

Agenda

- Introduction
- Carbon-in-Ash Instrument
- Mill Runback Calculator.
- Combustion Optimization
- Soot Blowing Optimization.
- Startup Optimization
- Life-time Calculation
- Temperature State Space Control
- Life Steam Flow Calculation
- Unit Control
- Energy Optimizer
- Process Quality Monitoring
- Loop Performance Monitoring
- Energy Efficiency Consulting

Only 20% of primary energy generates economic value
The rest is lost to conversion processes, transportation and operational inefficiencies



Motivation for optimization

Benefits

- Reduce fuel consumption and emissions
- Increase flexibility
- Identify and rectify equipment problems
- Improve predictive maintenance and availability
- Optimize asset lifecycles

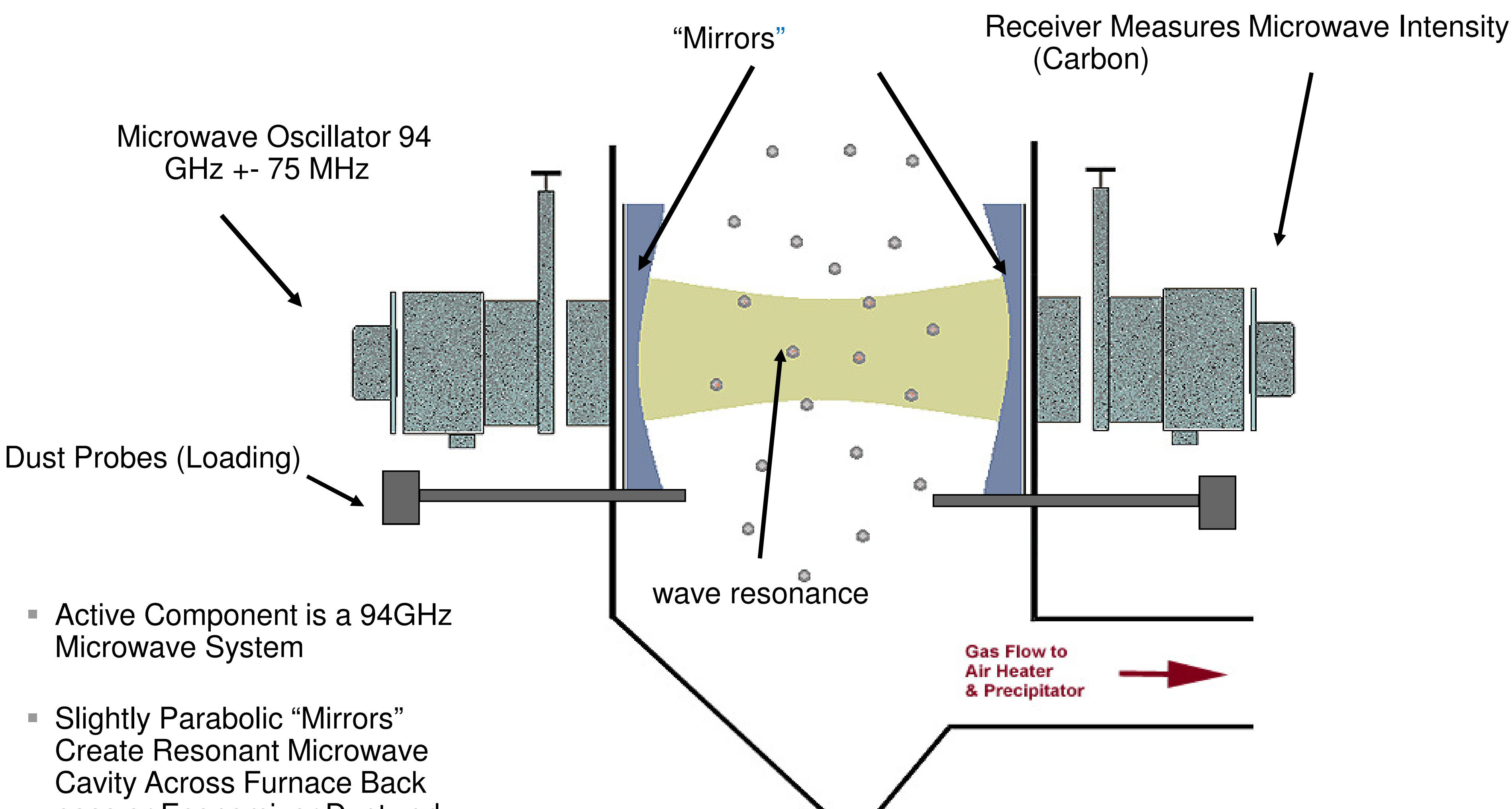
Measures

- Tune control loops
- Optimize the combustion process and improve boiler controls
- Optimize ramp rates, low load running and startups
- Optimize operation of multiple generating units
- Monitor and predict plant performance
- Issue early warnings for equipment diagnosis and preventive maintenance

Carbon In Ash Instrument
Basics

- Majority of the combustible portion of the ash accounting for the energy loss is simply unburned carbon.
- Unburned carbon is a highly variable parameter which is dependent upon coal type, load, fuel and air distribution, and other boiler-specific factors, the need for on-line real-time measurement has become more critical in combustion optimization process
- ABB Carbon In Ash Instrument (CIA) provides a true real-time and representative measurements of the unburned carbon in the fly ash for utility power plants

Carbon In Ash Instrument
ABB's Technology Edge!



- Active Component is a 94GHz Microwave System
- Slightly Parabolic "Mirrors" Create Resonant Microwave Cavity Across Furnace Back pass or Economizer Ductwork
- Total Ash Loading Determined by "Dust Probe"

<u>CIA Output</u>

Carbon/Ash Loading @ %

OR

Carbon @ g/m^3

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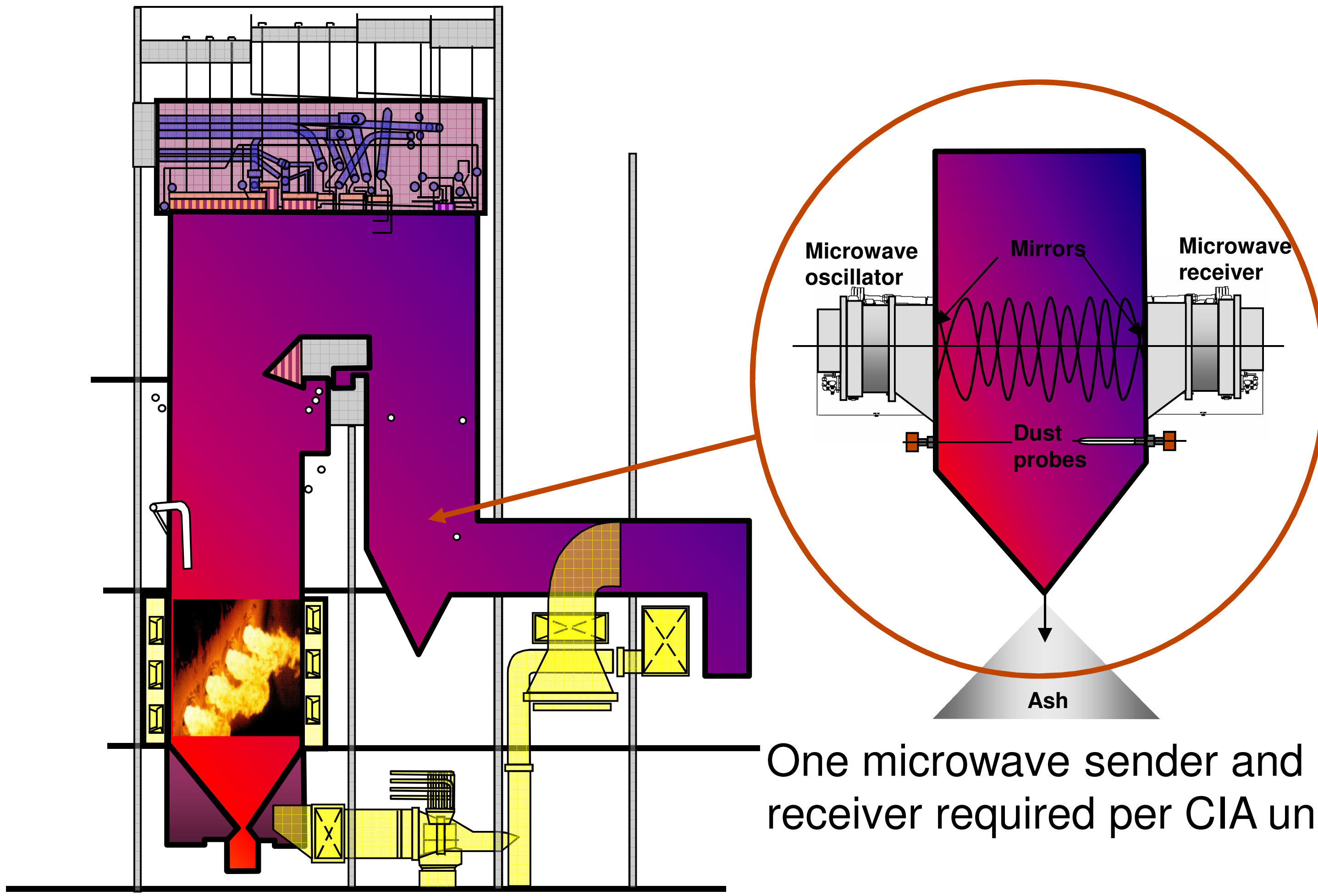
Carbon In Ash Instrument
Installation



One microwave sender and receiver required per CIA unit

Carbon In Ash Instrument
Benefits

Increased

- Increased combustion efficiency
- Increased quality of Fly Ash resulting in better sale price!
- Improved Mercury capture
- Loss of Ignition availability
- Balanced plant efficiency

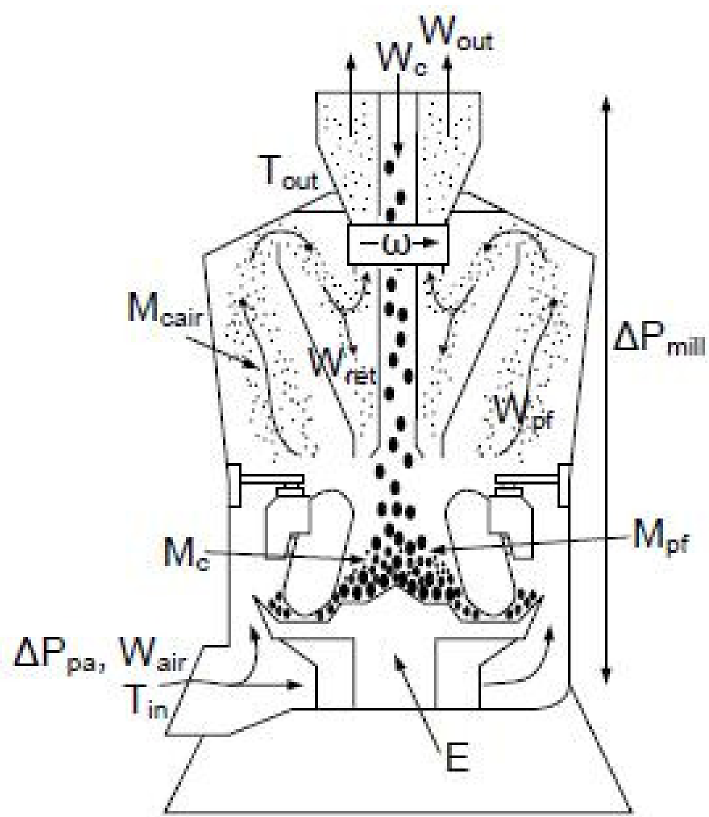
ABB's Carbon in Ash Instrument

- Reduced operating cost
- Reduced amount of Fly Ash & reduced Land Filling
- Reduced manual LOI procedure

Reduced

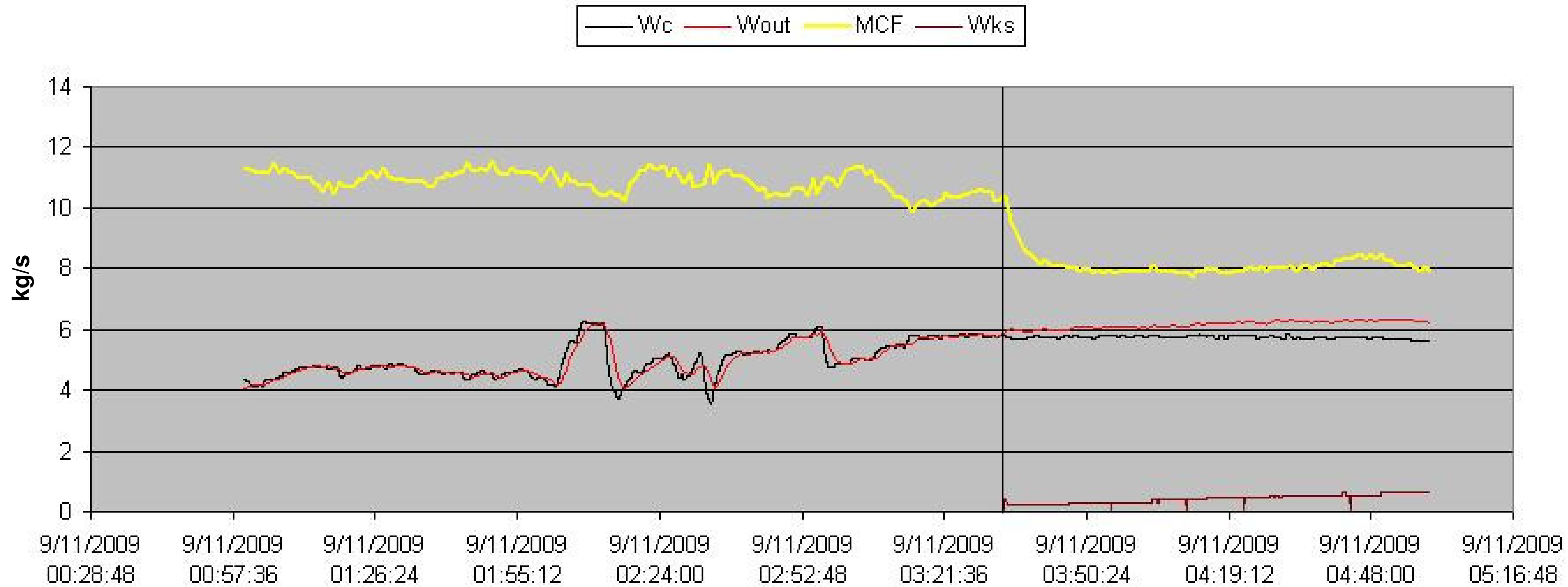
OPTIMAX® Performance
Mill Run Back Calculator

- Run-Back Calculator based on physical model of the mill
- Outputs:
  - Maximal Drying capacity
  - Maximal grinding capacity
  - Moisture of coal / biomass
- Implemented on controller



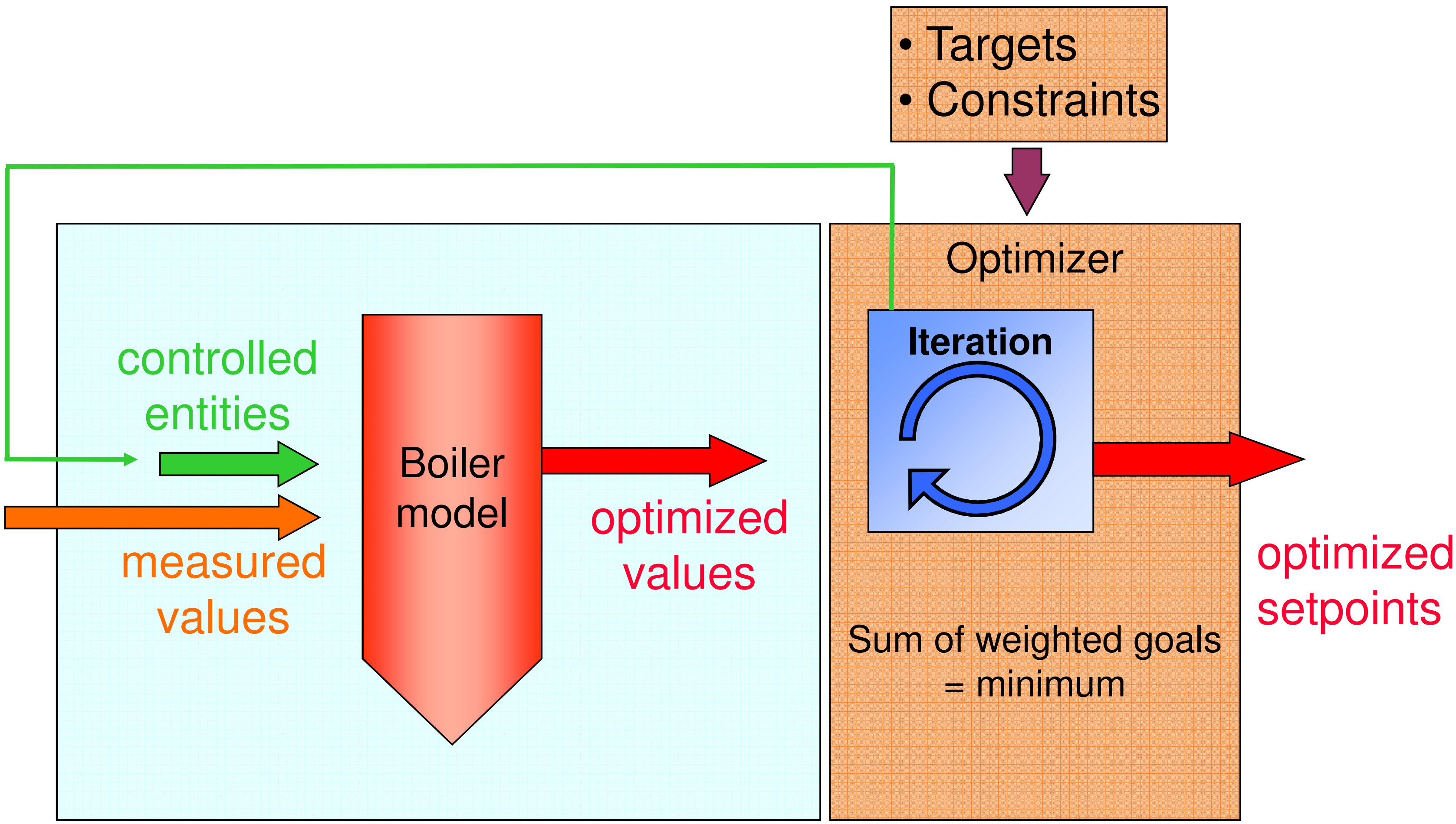
Referenz:
P. Niemczyk et al: Derivation and validation of a coal mill model for control

OPTIMAX® Performance
Mill Drying capacity



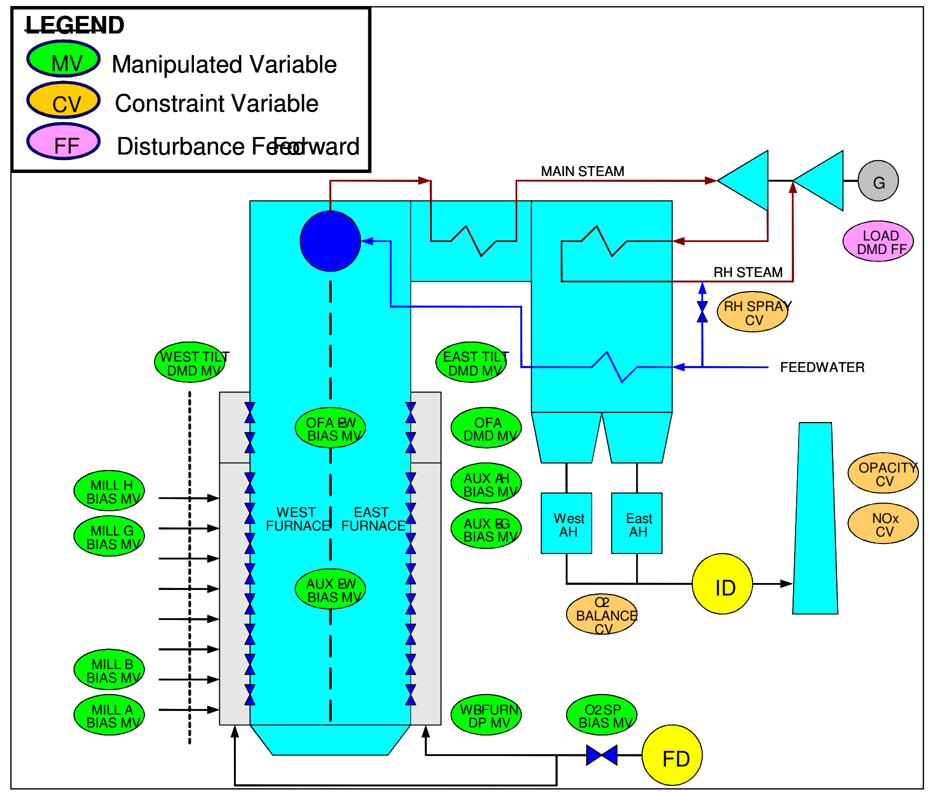
- MCF: Max. coal/biomass addition
- 3:30: Addition of Biomass

Combustion Optimization Principe



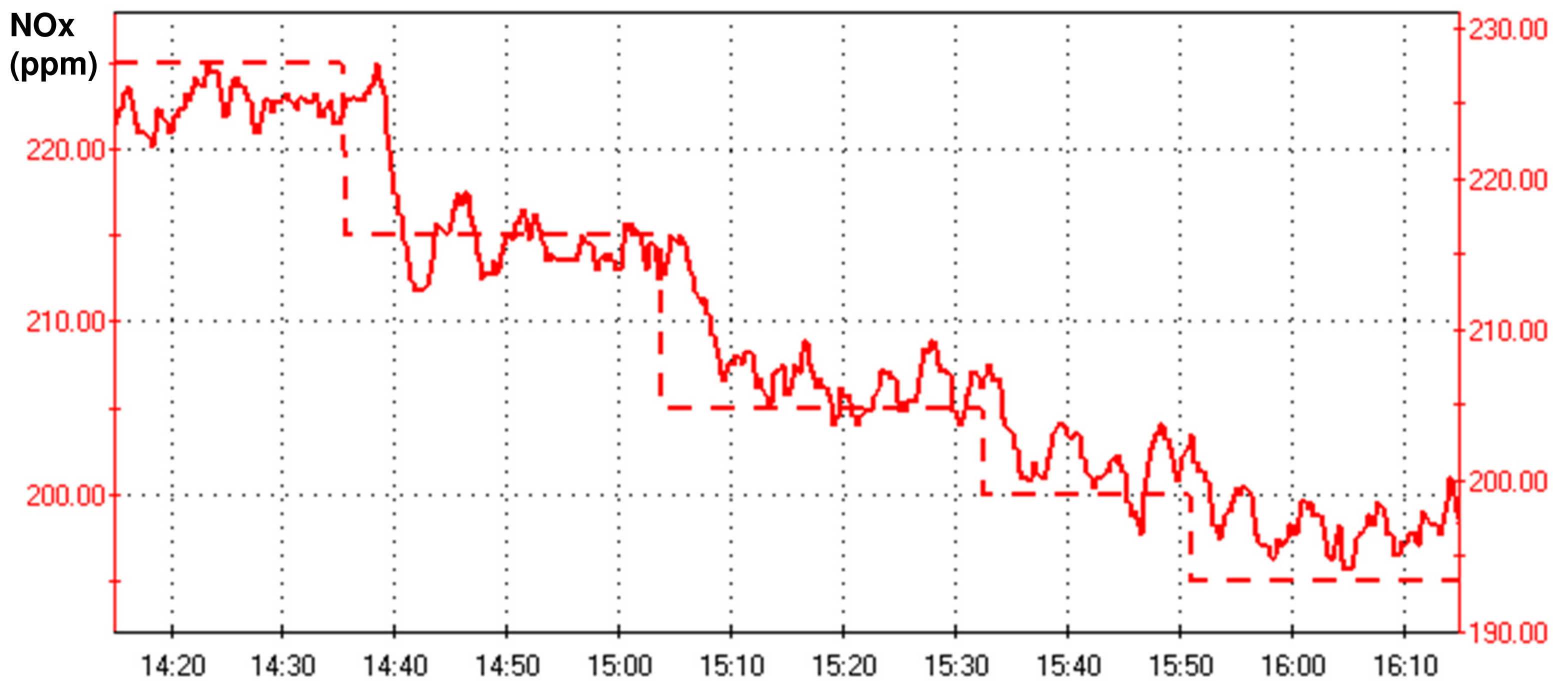
Combustion Optimizer
Typical Scope

- NOx – maximum constraint, main objective
- Opacity – maximum constraint, noisy value
- O2 imbalance – delta O2 between furnaces, controlled with furnace biases on Aux Air and OFAD
- Actuator constraints – must keep base DCS loops in operating range, usually below a max output
    - Spray valves
    - Dampers



Combustion Optimizer
Reference: reducing NOx

- Max limit lowered sequentially by 10 ppm from 225 to 195



Lifetime Monitoring
Motivation

Boilers

- Increasing peak operation results in additional load cycles on individual components
- New component materials allow higher steam parameters
- Optimum plant or boiler operation is achieved when the:
  - Operation is safe, and when there is
  - Good Agreement between design and the current operating lifetime consumption

Turbines

- Requirement for operational safety and high availability
- Obligation to prevent highly stressed components from failing,
- due to:
  - Permanent loads such as high pressures and temperatures
  - Centrifugal forces in a high temperature range
  - Low-frequency alternating loads

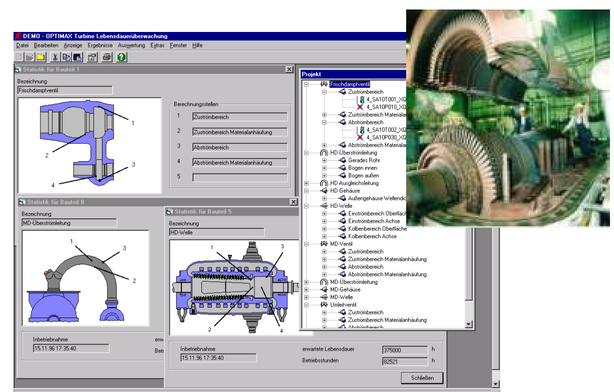
Lifetime Monitoring
Boiler and Turbine

Features

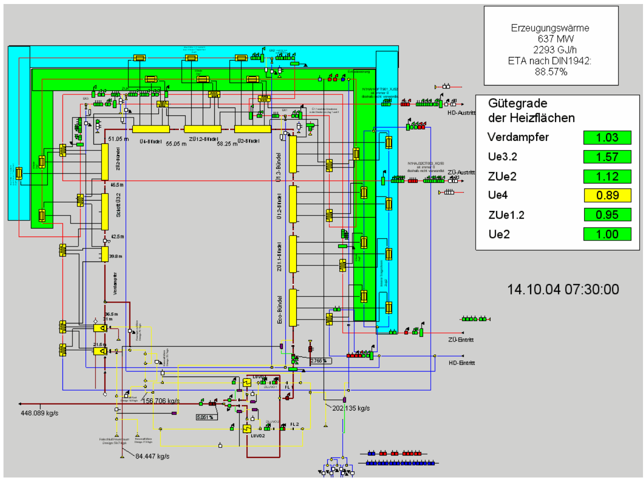
- Online calculation of lifetime consumption of critical components
- BoilerLife certified by TÜV
- Calculations according to international standards
- Online reporting on lifetime status of critical components

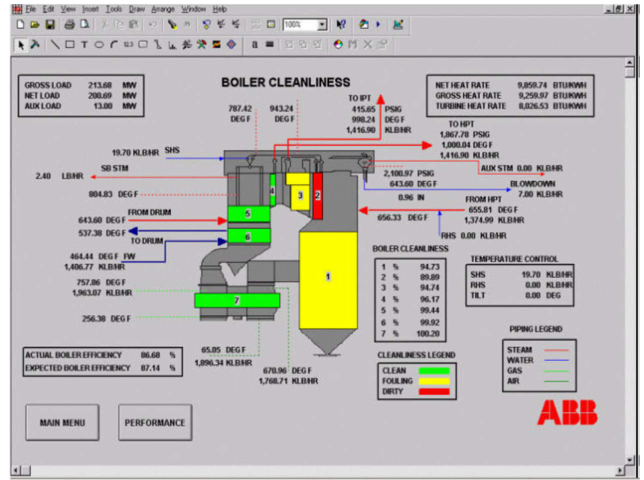
Benefits

- Improving maintenance planning
- Ensure that components will not fail or need replacement too early
- Certified reporting to safety authorities



Soot Blowing Optimization
Model based calculation of heat exchangers

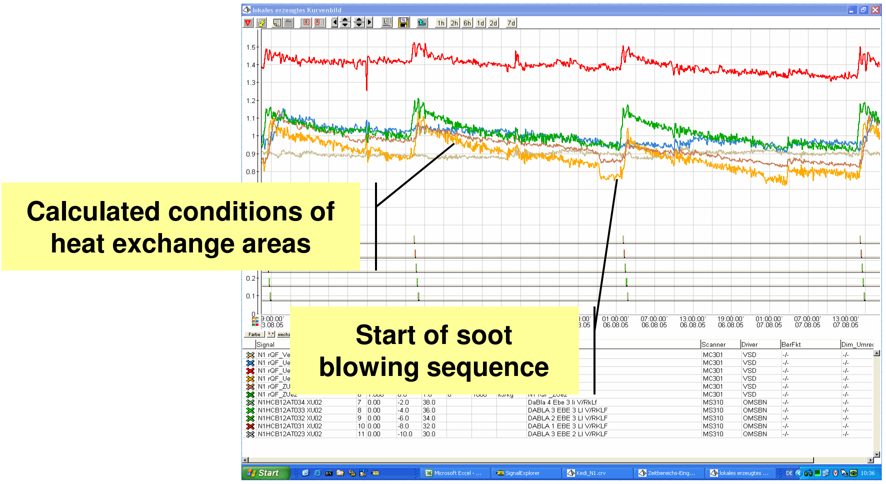


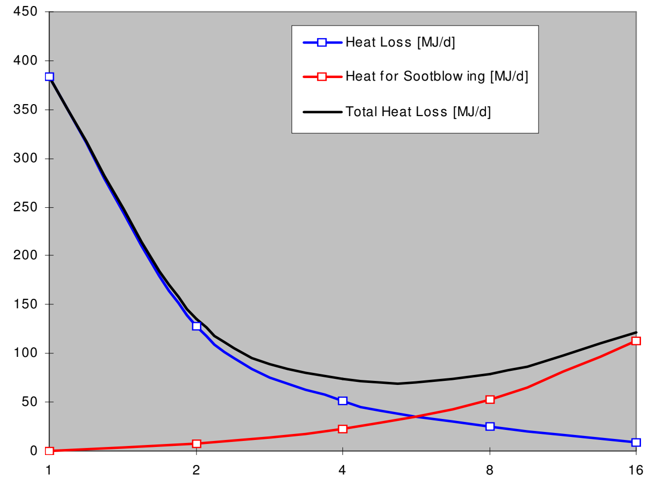


Activation signals for individual soot blower groups are:

- Temperature limits
- Soot blower steam consumption
- Water consumption of water injectors
- Boiler efficiency
- Injection rates of intermediate superheaters
- Pressure losses
- Blower performance

Soot Blowing Optimization
Calculation results with a detailed boiler model





Features

- Provides operator guidance as to when to initiate a soot blowing sequence
- Calculates cleanliness factors per section
- Measures heat transfer efficiency
- Applies to furnace, walls and convective sections

Benefits

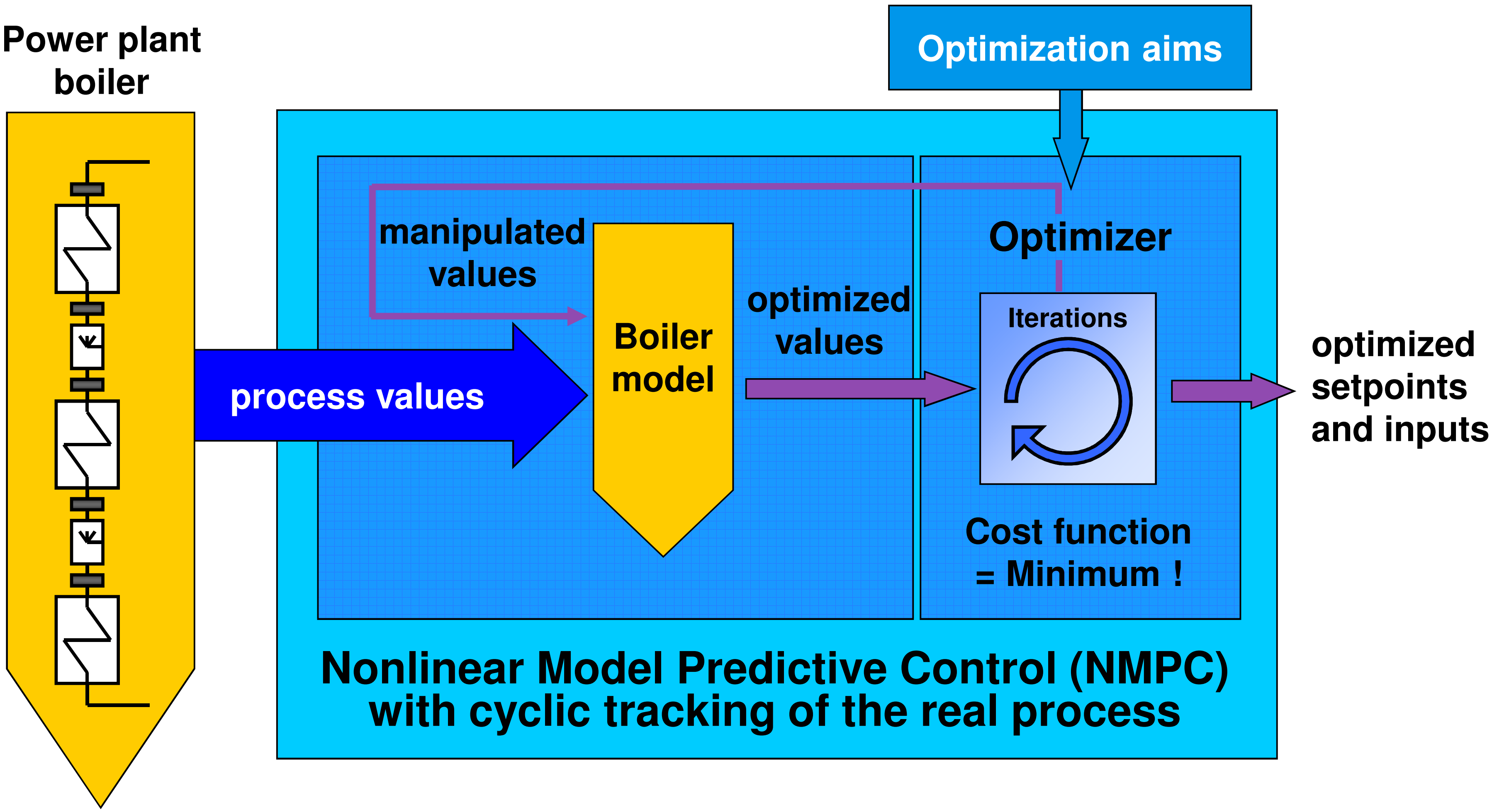
- Easy-to-spot effects of minor changes in soot blowing sequences
- Significant heat rate savings
- Increase in long term plant performance
- Online computation of surface cleanliness
- Typical payback time < 2 years

BoilerMax
Boiler start-up Optimization

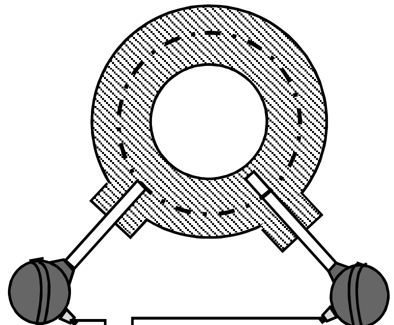
Benefits:

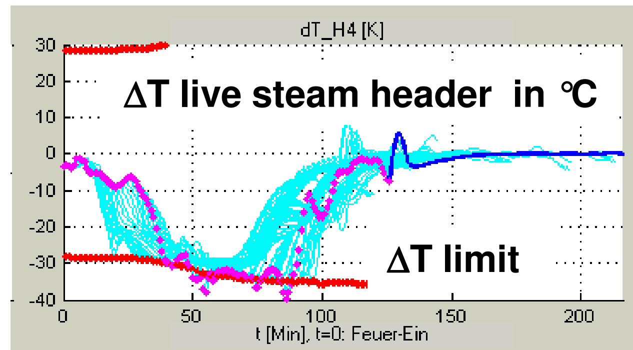
- Shorter start-up and shut-down time reduces fuel consumption
- Faster load response to load dispatcher, advantages in energy trading
- Explicit consideration of thermal stresses in thick-walled components, control of temperature variances during start-up
- Earlier warm-up and speed-up of the steam turbine and therefore earlier grid synchronization possible

BoilerMax
Functional principle



BoilerMax
Determination of thermal stresses





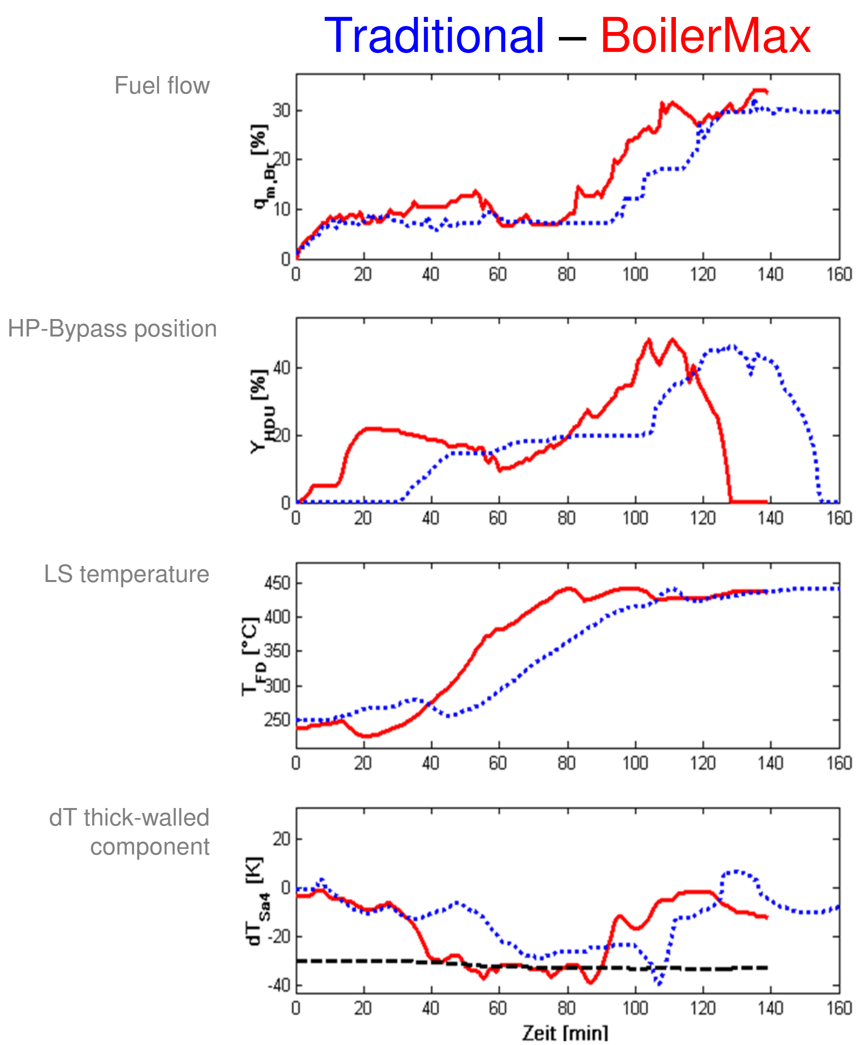
T_i: inner temperature
T_m: mid temperature

$\Delta T \approx T_m - T_i$

Principle:

- Temperature difference ΔT is indicator for thermal stresses
- Measurement of ΔT between inner surface and the mean diameter of the annular cross section of thick-walled components
- Alternative 1: determination on non-heated surface
- Alternative 2: indirect determination from steam temperature gradients

BoilerMax
Enhanced start-up phase



- Traditional start-up to comply with design limits
- BoilerMax start-up allows exploitation of design limits for more efficient process control:
  - Based on process model
  - NMPC technology
  - Predictive coordination of multiple variables
  - Online optimization in real-time

Up to 15% savings due to fast and low-stress boiler start-up

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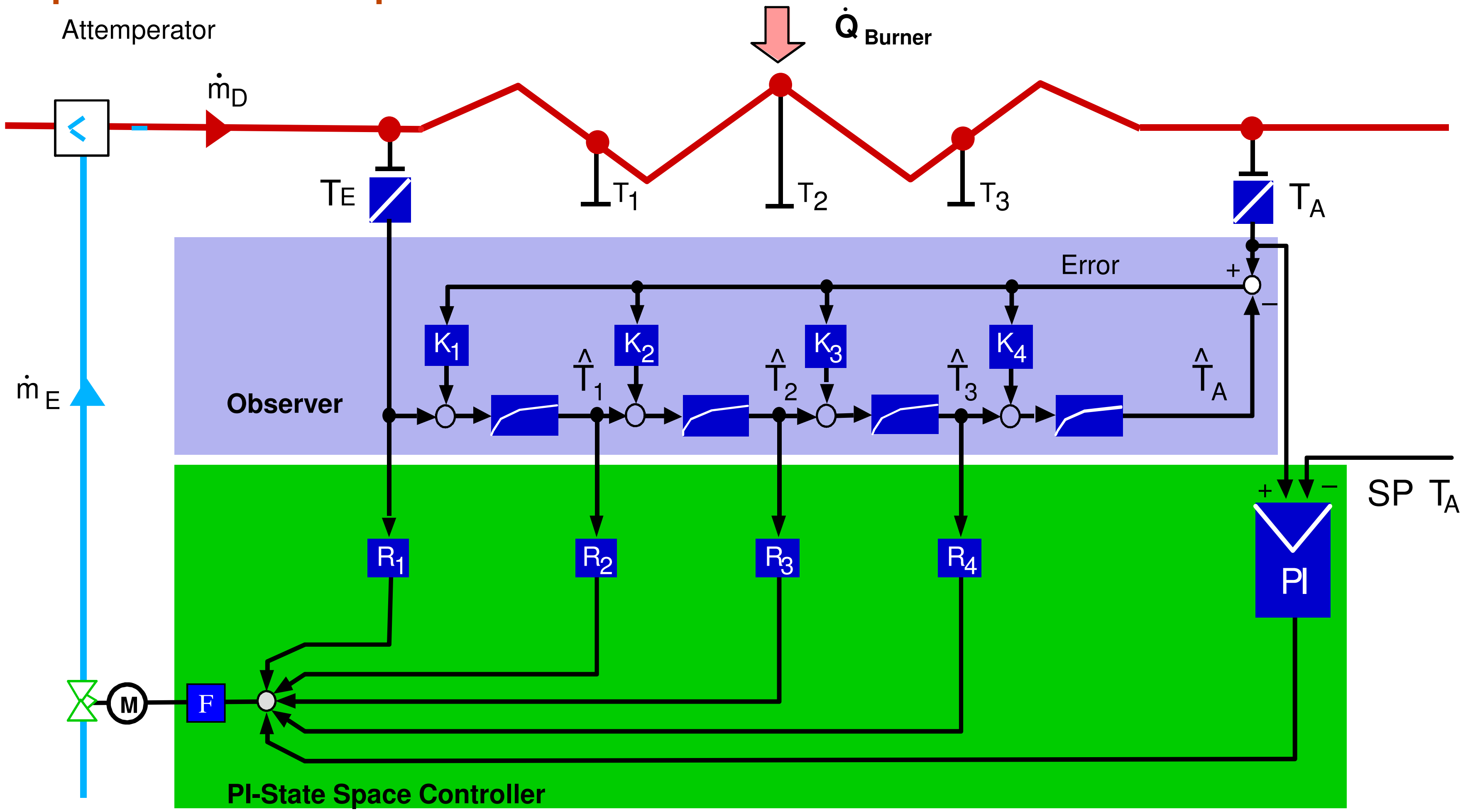
State Space Controller
Improved Temperature Control



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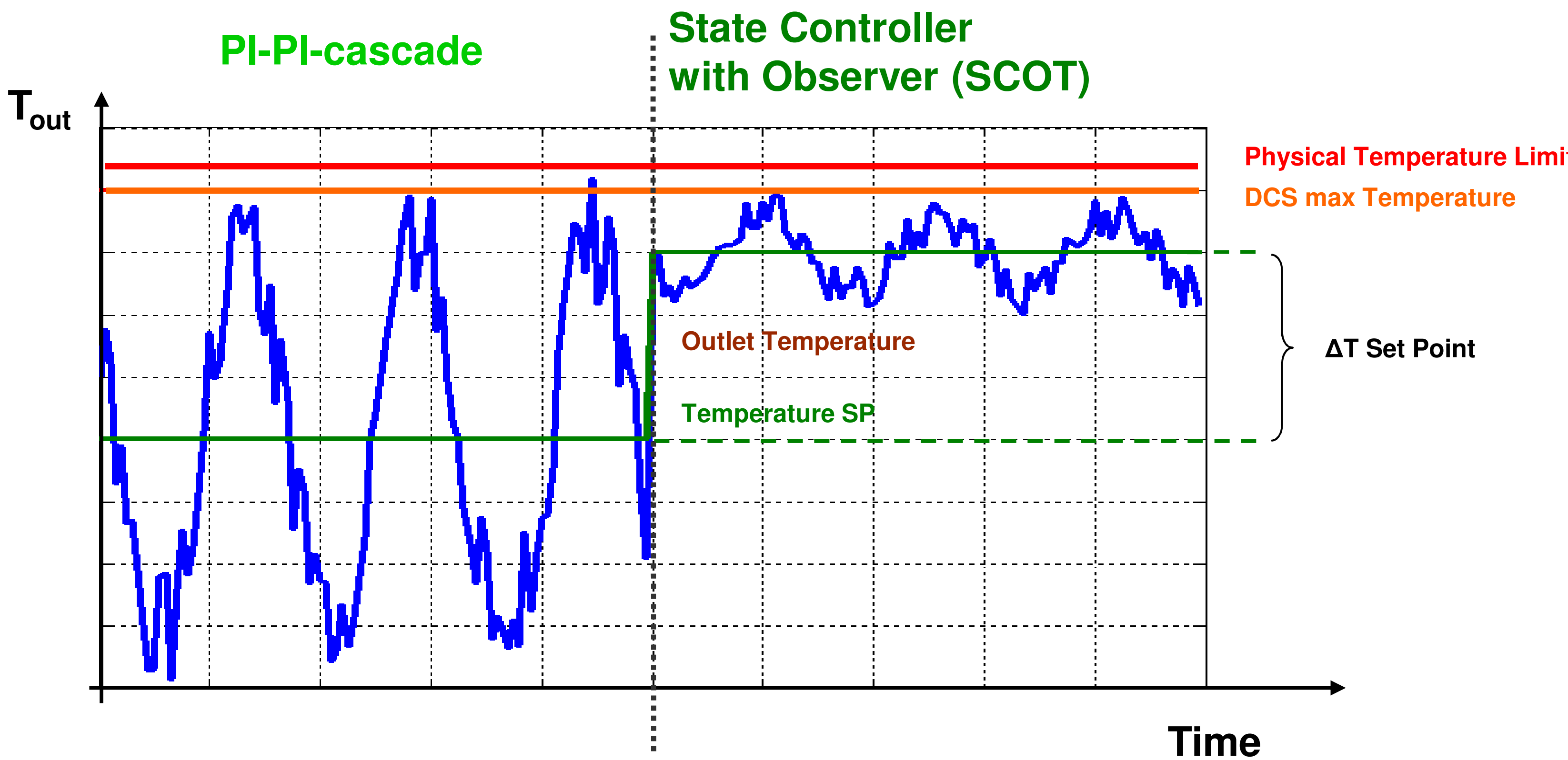
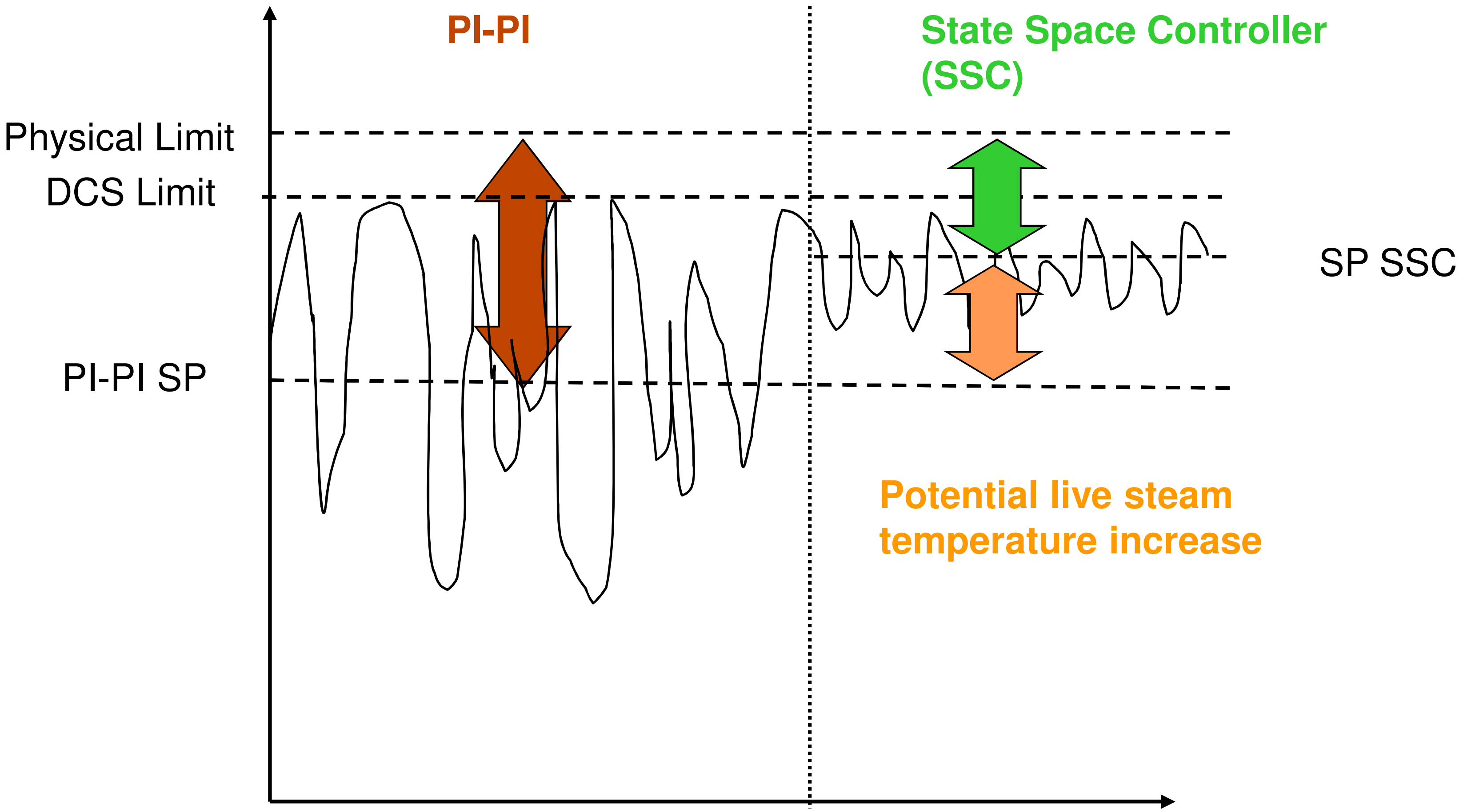
State Space Controller
Improved Temperature Control



- Increasing the live steam and rehated steam operation temperature results in an immediate increment of unit efficiency
- With a higher set point, however, the margin between the operation point and max. admissible temperature is reduced
- This is no problem thanks to the improved performance that the state controller delivers

OPTIMAX® State Space Controller
Improved Temperature Control



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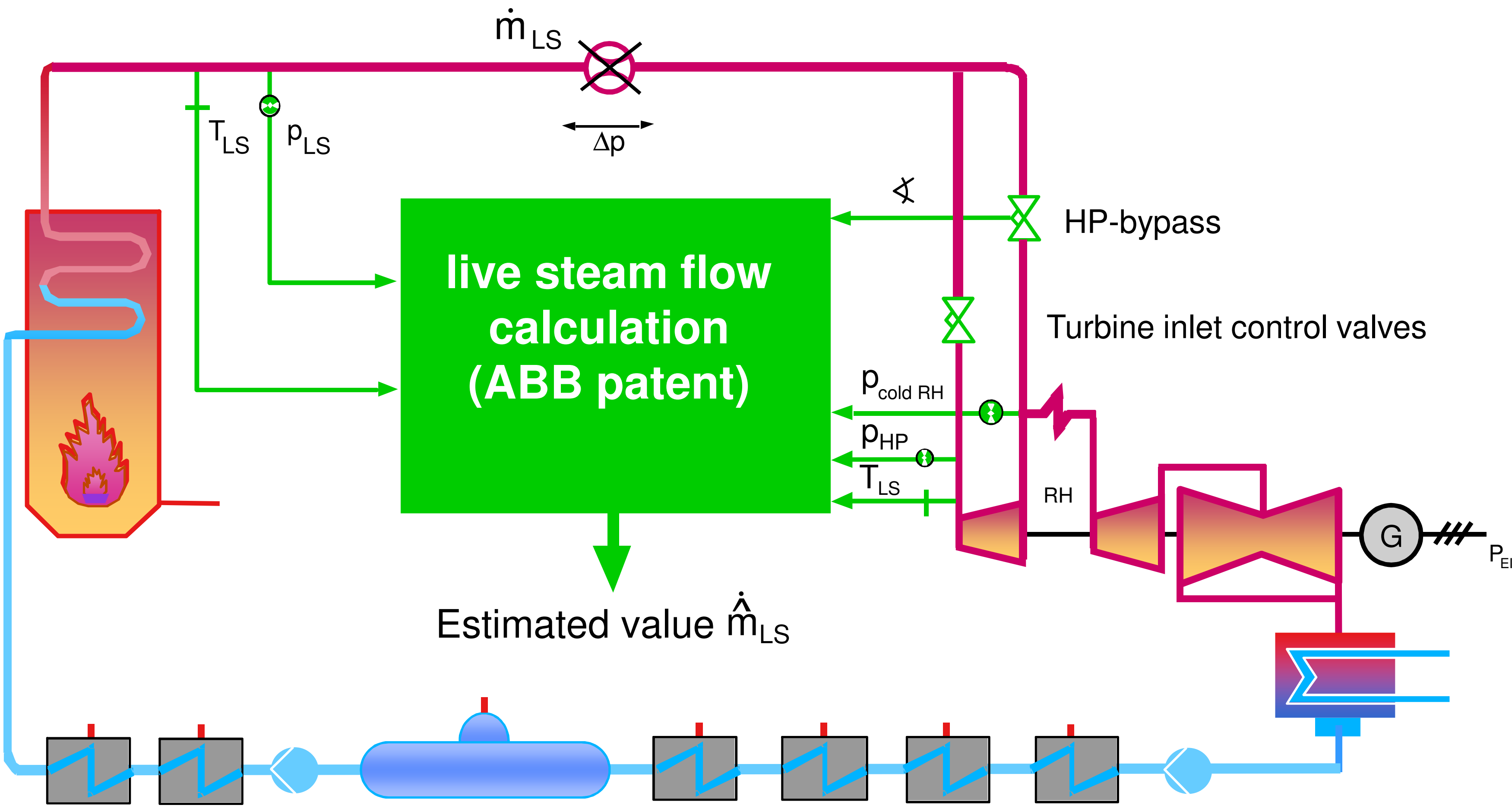
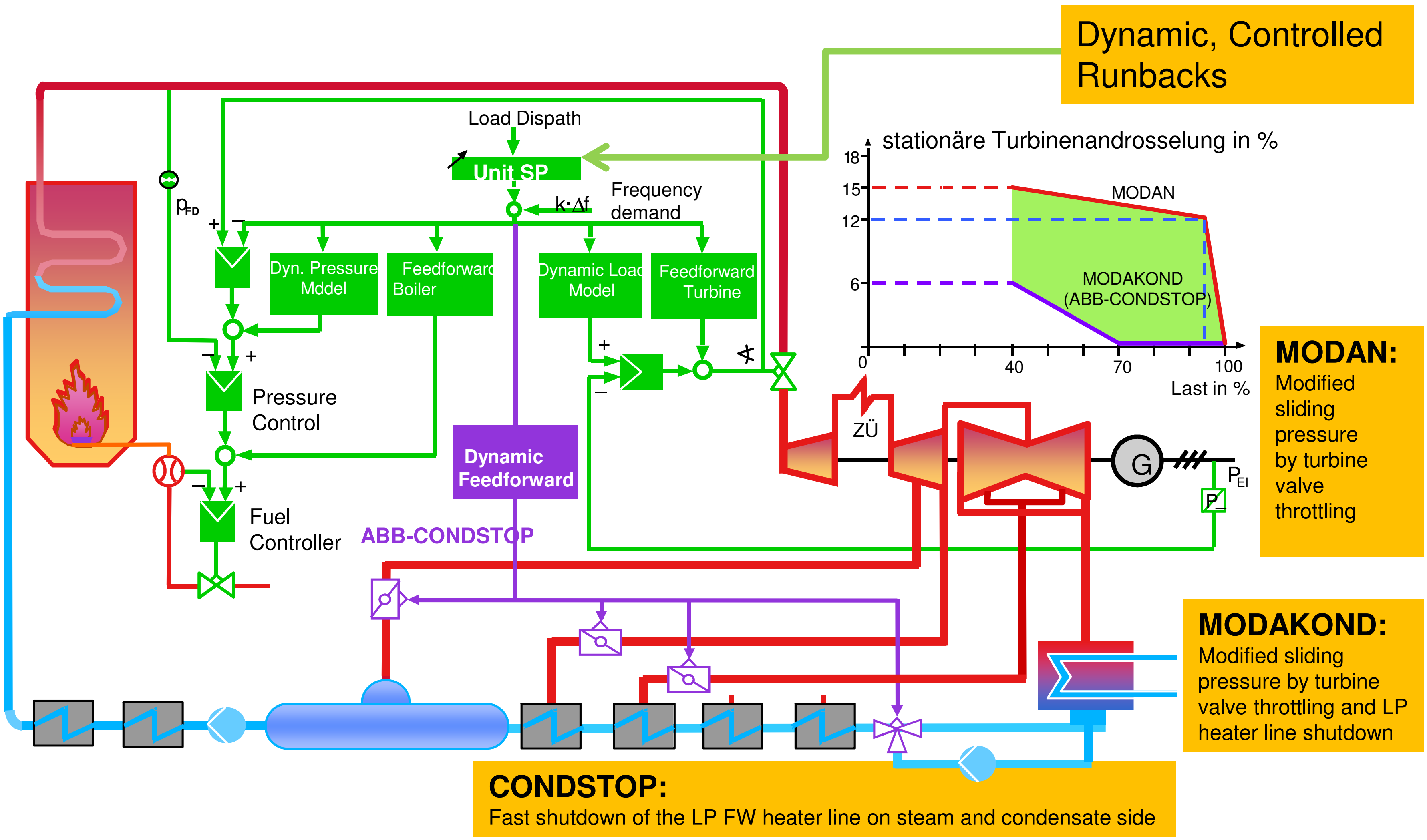
Life Steam Flow Calculation
Reduction of Throttling Losses



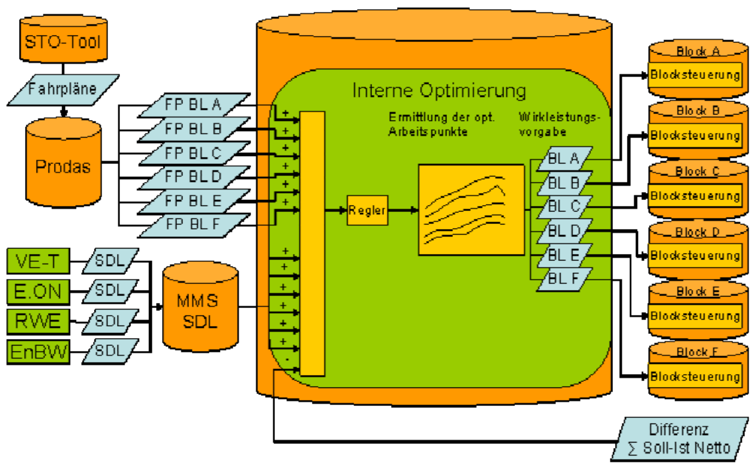
Unit Control
Flexible and Reliable Operation



Energy Optimizer

- Flexible exploitation of different production units
  - Gas turbines
  - Boilers
  - Steam turbines
  - Different fuels
- Varying operational policies.:
  - Prio steam production
  - Prio el. production
  - Start/Stop of boilers and turbines
- Energy Optimizer: Online-Optimization considering process constraints and market needs

Reference 1: Internal Optimization Jänschwalde
Pooling of six 500 MW units



VATTENFALL

Advantage of Multi-unit optimization

- Exploit communication network between management system and unit control system
- Real-time optimization of set points and secondary frequency control
- Fast and optimal reaction to fulfill production task, incl. gradients and timing of load ramps
- Goals:
  - minimize fuel consumption and CO_2-emmissions
  - increase flexibility

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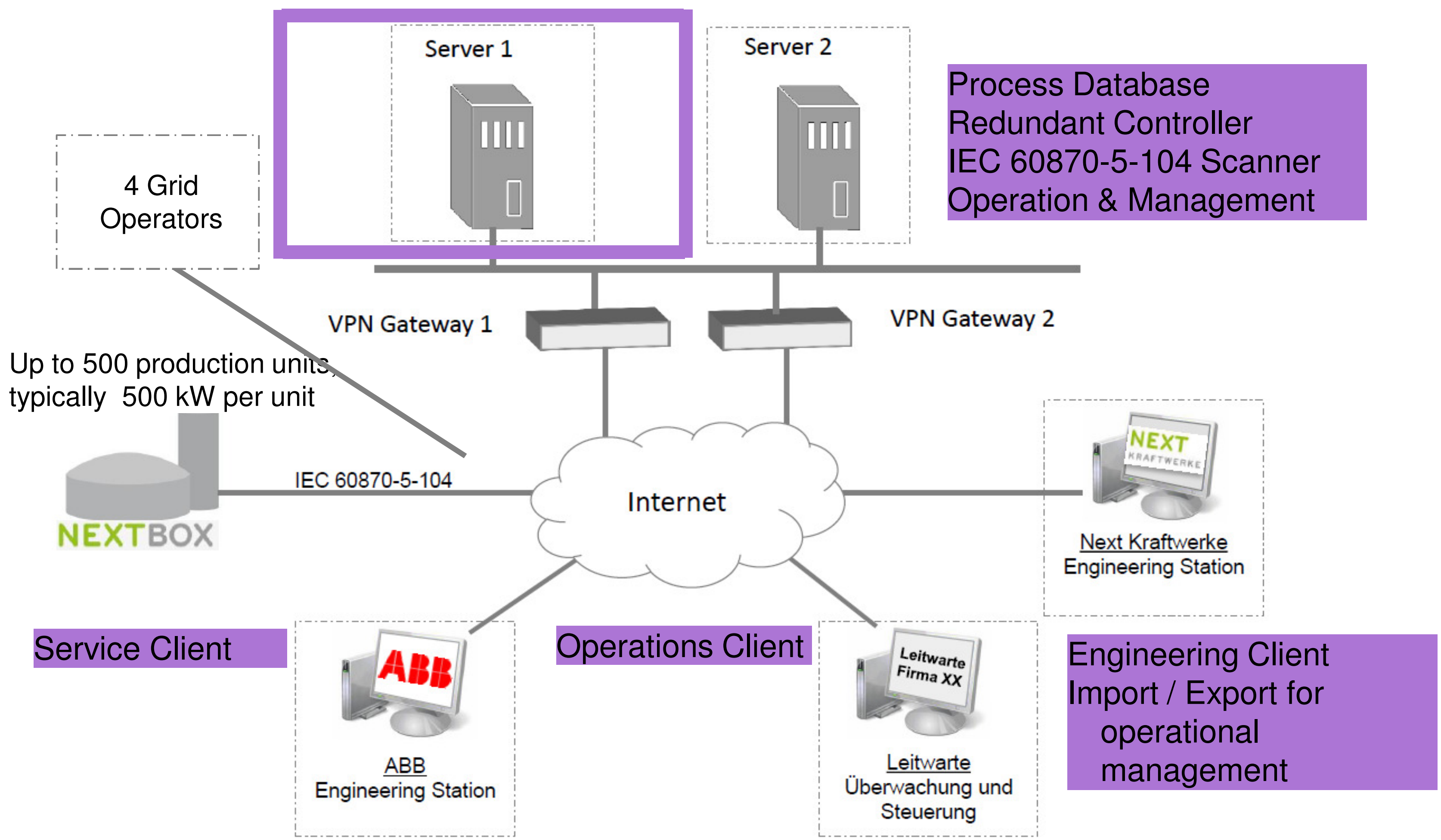
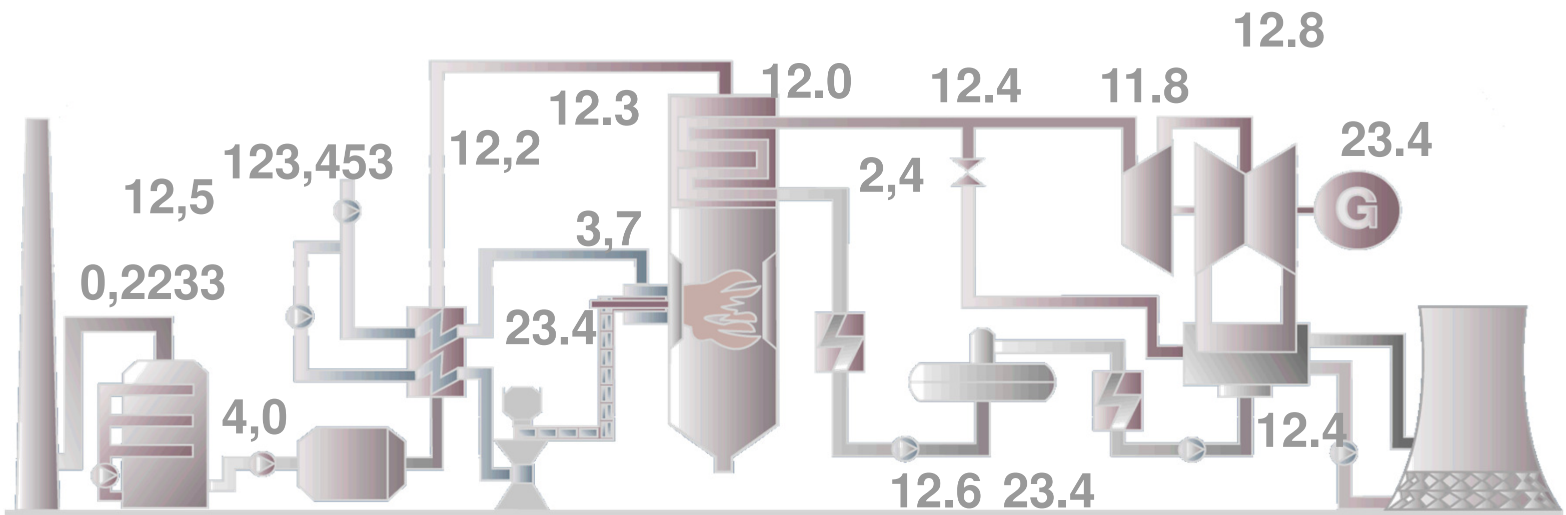
Reference 2: Pooling of up to 500 biogas plants



OPTIMAX® PlantPerformance
Starting point: Monitoring of Process Values in DCS

- Process values alone usually give no information about the efficiency or the

  process quality of a plant



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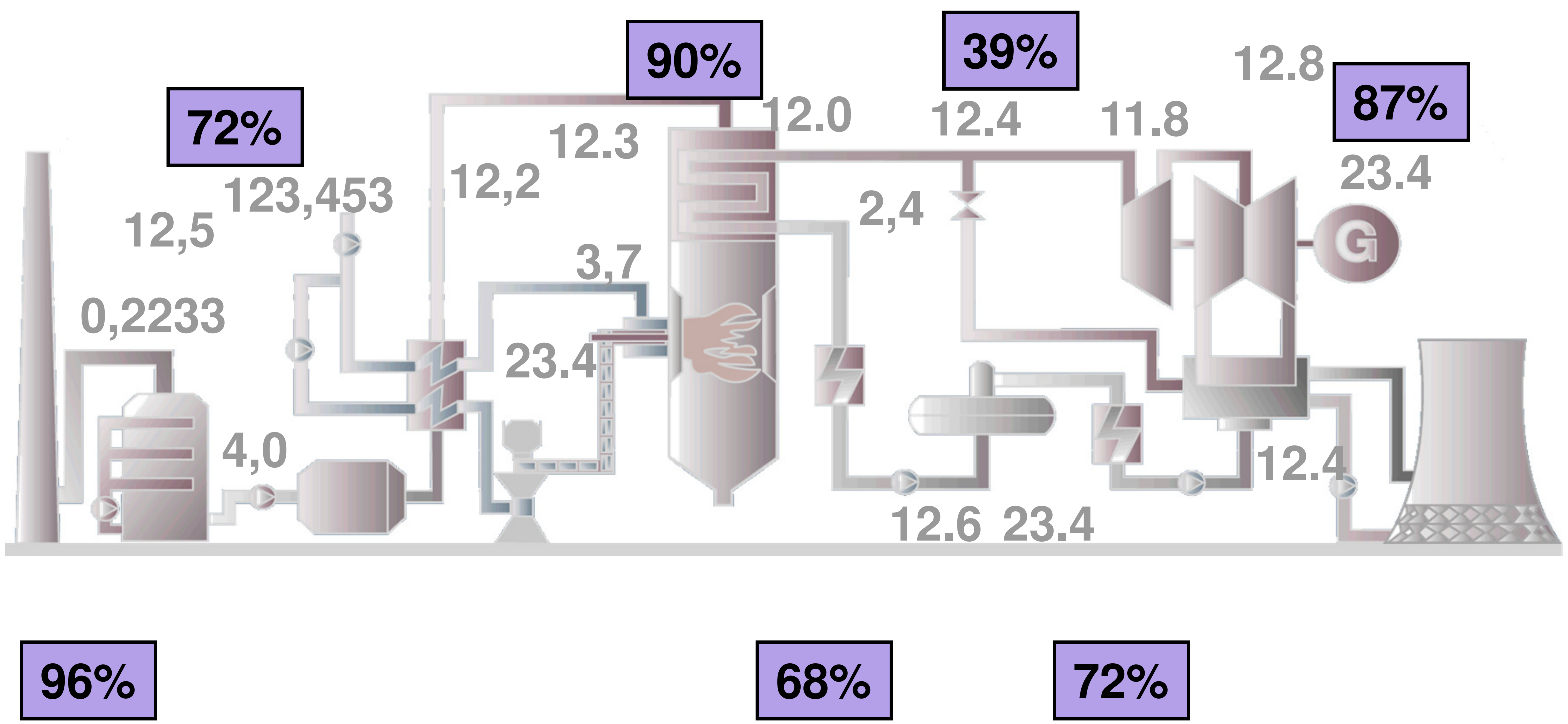
OPTIMAX® PlantPerformance
Determination of Performance Indicators

- Performance indicators are determined by using multiple process values



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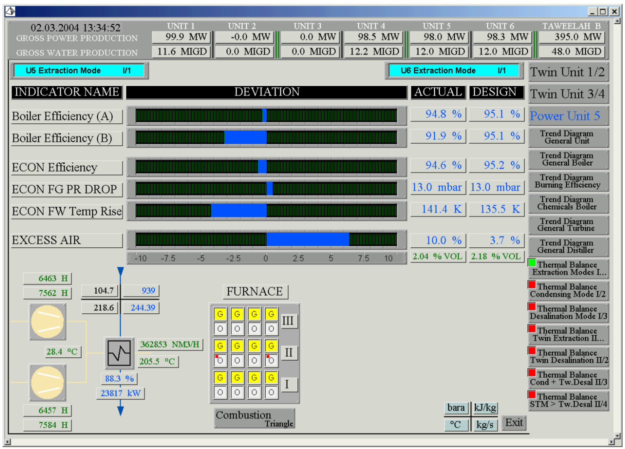
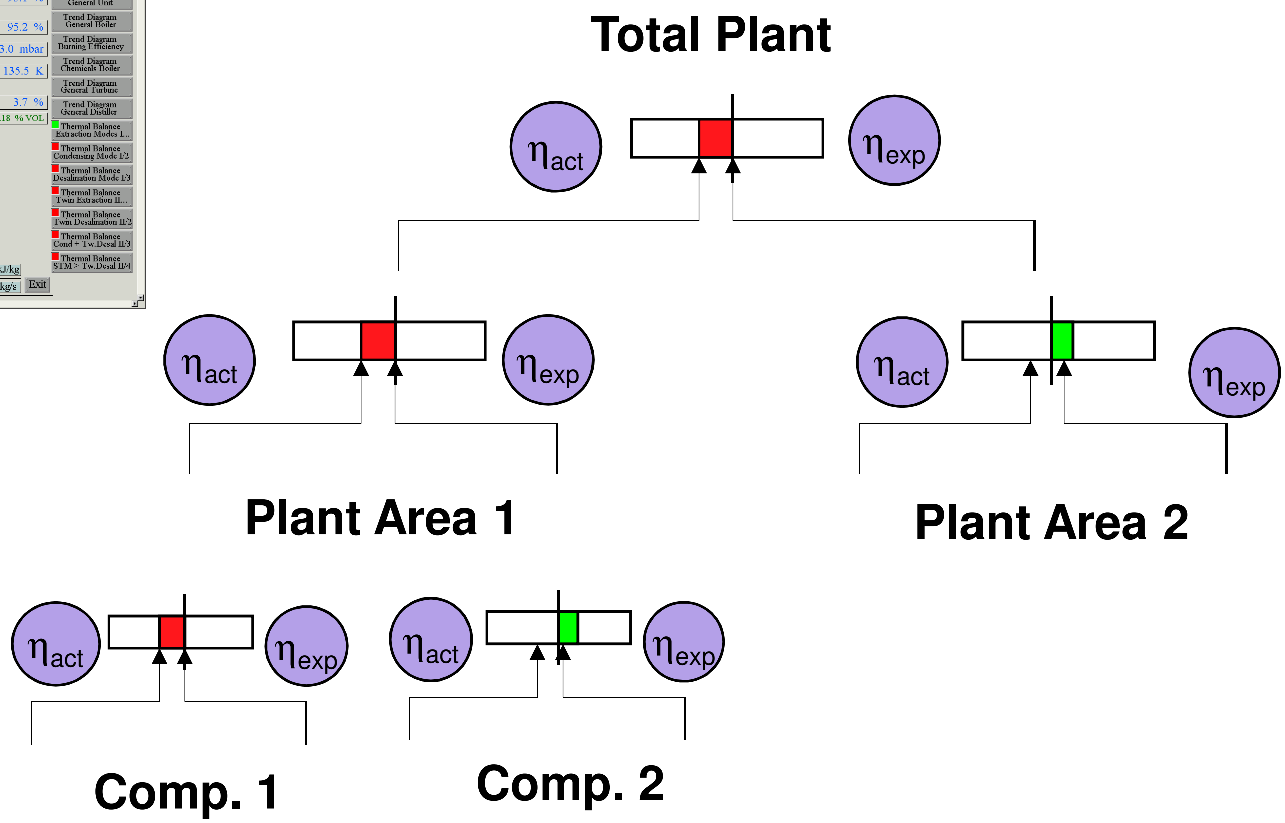
OPTIMAX® PlantPerformance

Identifying the origin of a performance deviation





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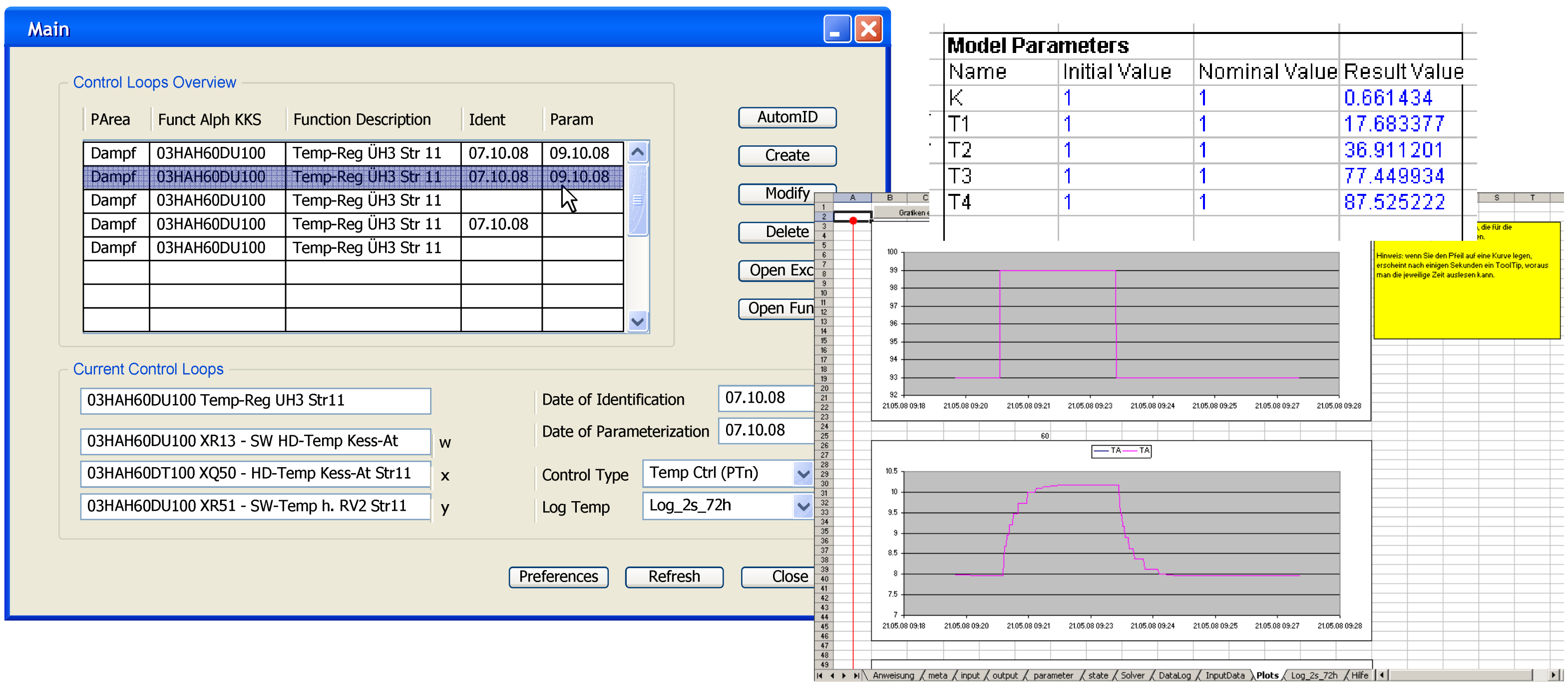
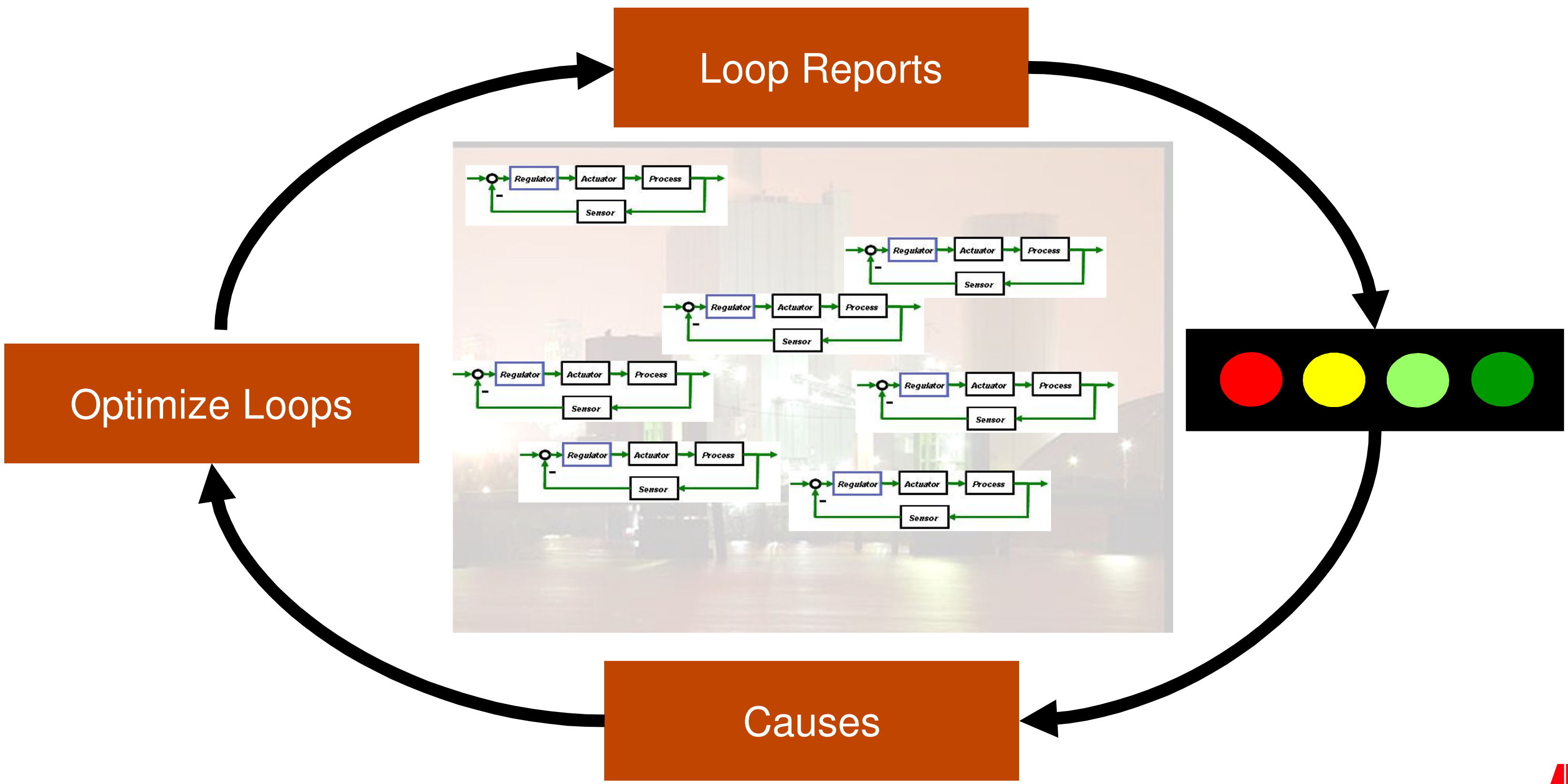
Loop Auditing

- Transparent commissioning of control through loop optimizer.
- Model based tuning of each individual loop with a well documented report for each loop
- Reports are available at any time during commissioning giving a fast and accurate account of the loop commissioning status.
- Fully integrated into the System 800xA



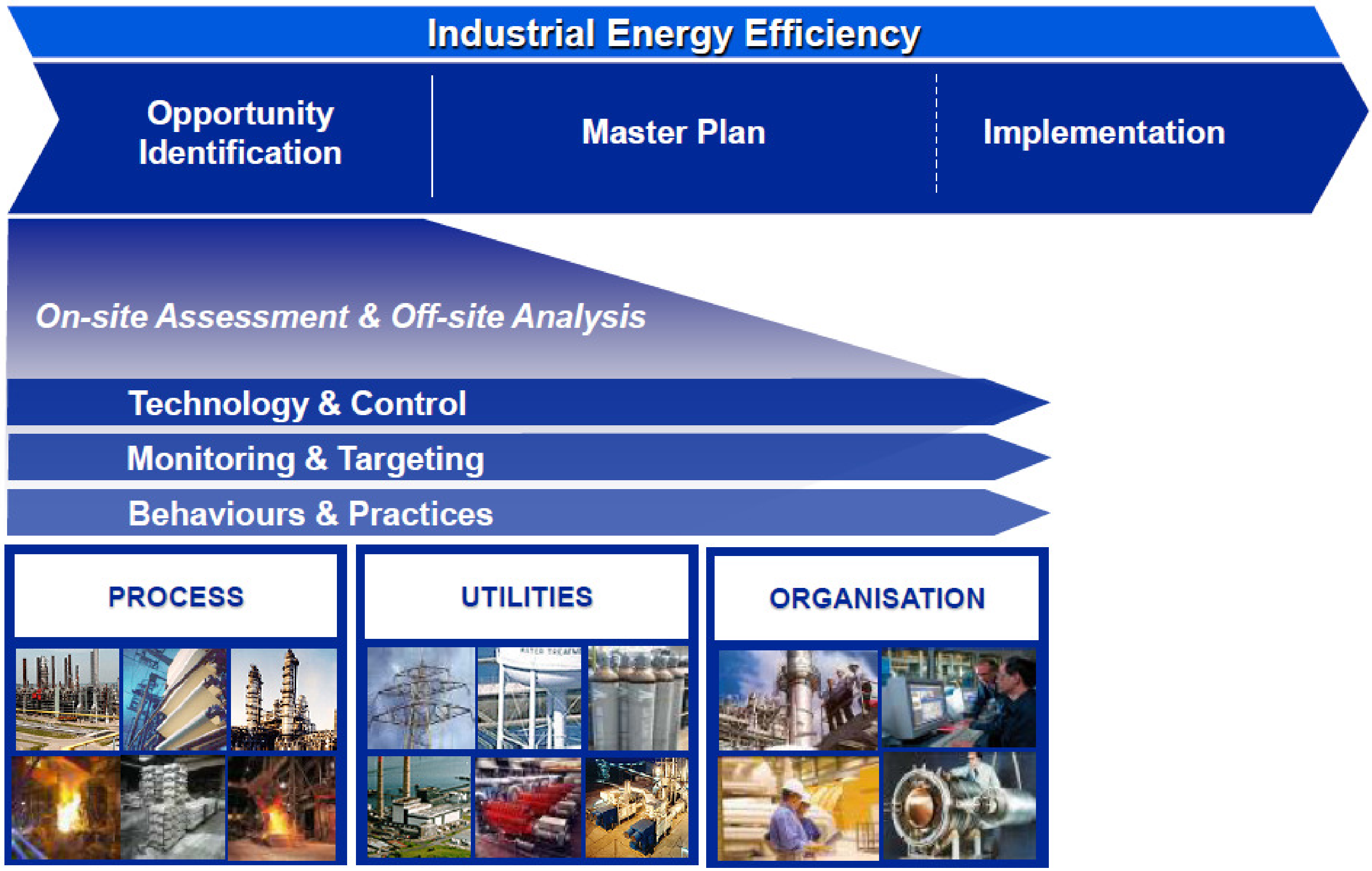
Loop Auditing

- Loop auditing given feedback on current control loop performance to detect worsening control loop behavior.
- Indicating on possible causes for the worsening of the control loop performance.



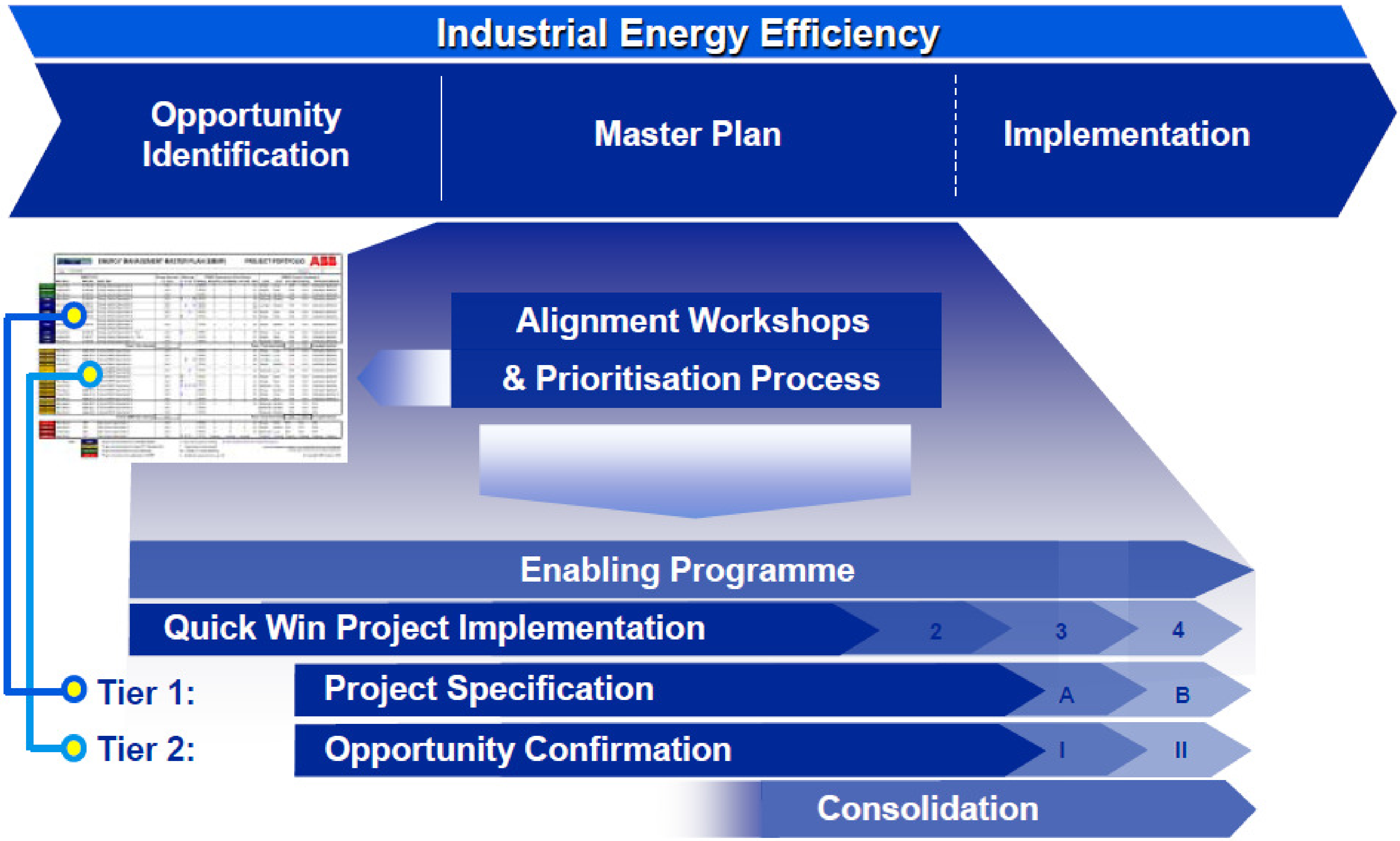
Power and Water Plant Operations

ABB Industrial Energy Efficiency (IEE) Assessment

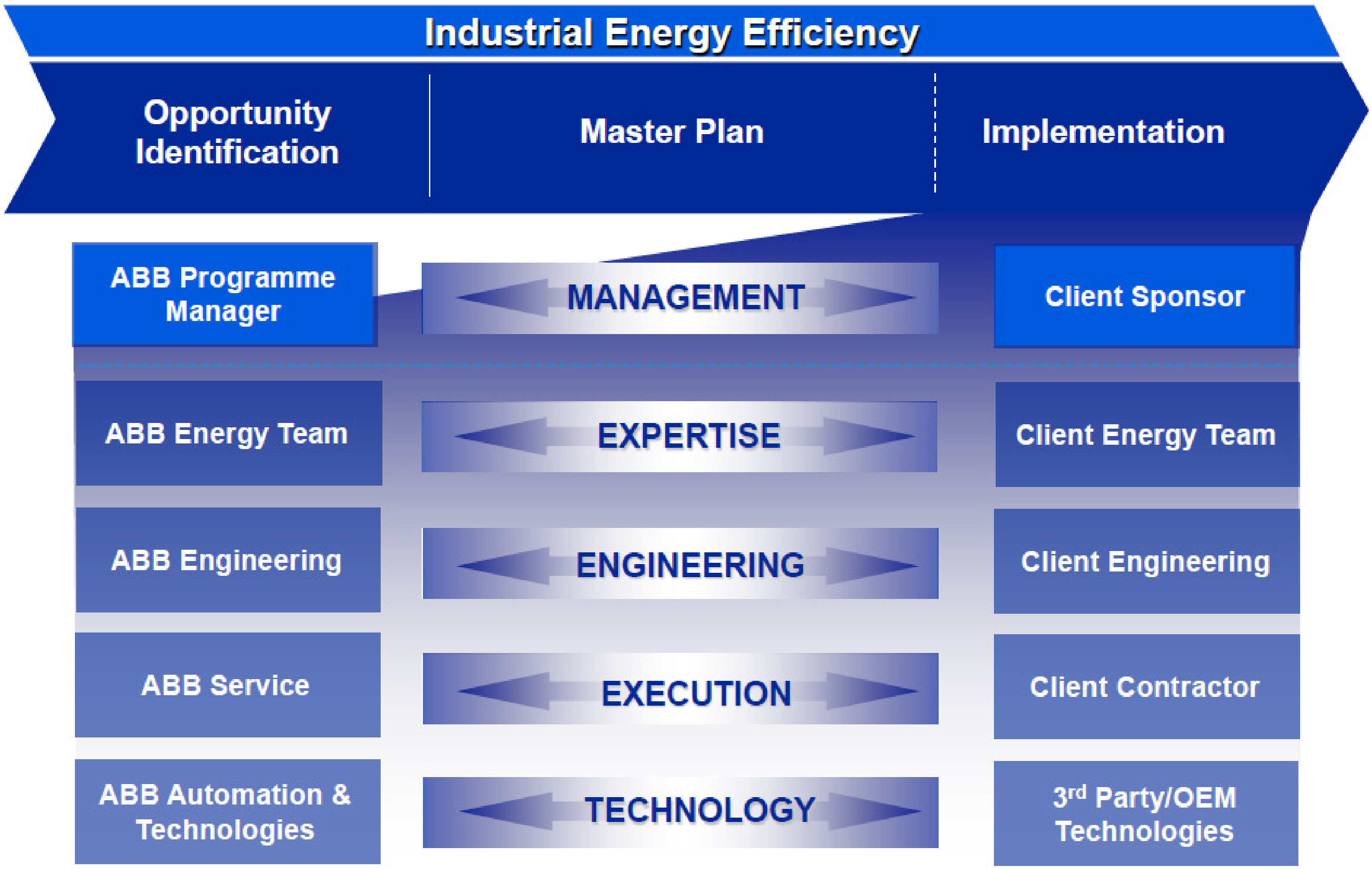


Industrial Energy Efficiency (IEE)

Master Plan



Industrial Energy Efficiency (IEE)
Implementation



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