Methods to Obtain Optimum Response, Efficiency and Emissions

metso

The challenge of change… *We must consider a life cycle operating approach*

Recognize deteriorating performance and act quickly!

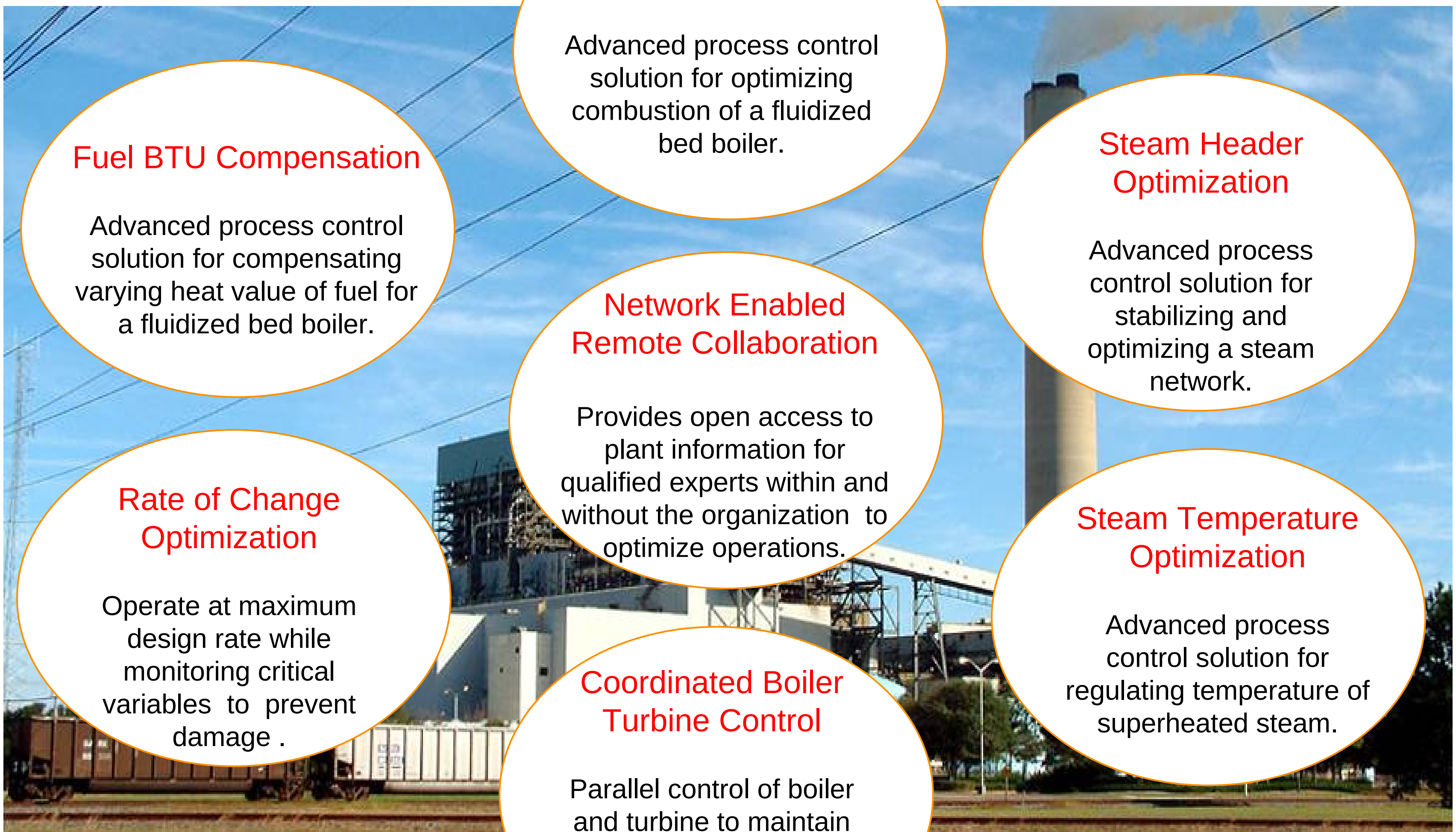
Keep informed!

Bring in the experts!

Consider remote supervisory systems!

Operation

Consider advanced process optimization…



Combustion Optimization

Advanced process control solution for optimizing combustion of a fluidized bed boiler.

Fuel BTU Compensation

Advanced process control solution for compensating varying heat value of fuel for a fluidized bed boiler.

Steam Header Optimization

Advanced process control solution for stabilizing and optimizing a steam network.

Network Enabled Remote Collaboration

Provides open access to plant information for qualified experts within and without the organization to optimize operations.

Rate of Change Optimization

Operate at maximum design rate while monitoring critical variables to prevent damage .

Steam Temperature Optimization

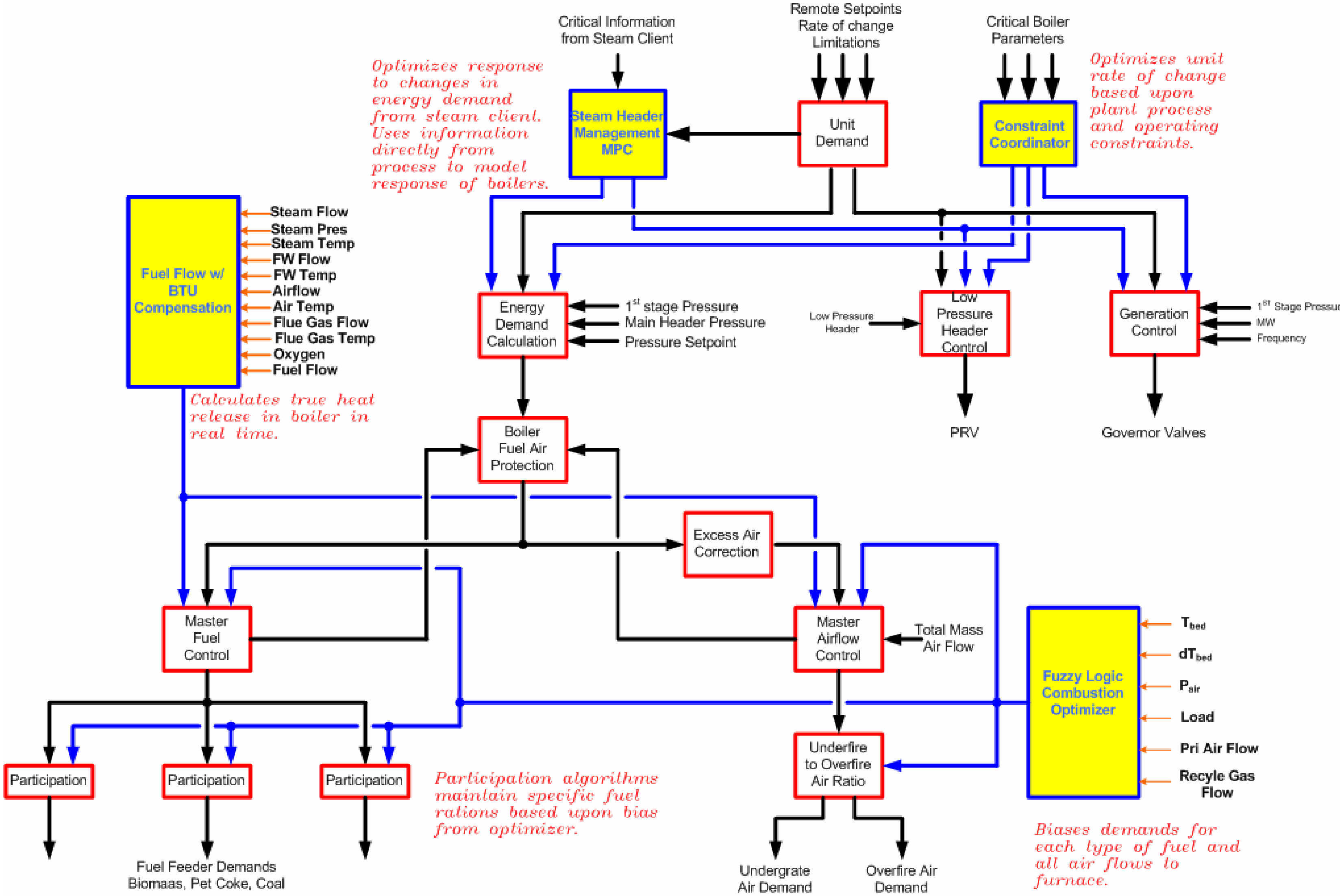
Advanced process control solution for regulating temperature of superheated steam.

Coordinated Boiler Turbine Control

Parallel control of boiler and turbine to maintain generation at setpoint operate at maximum rate

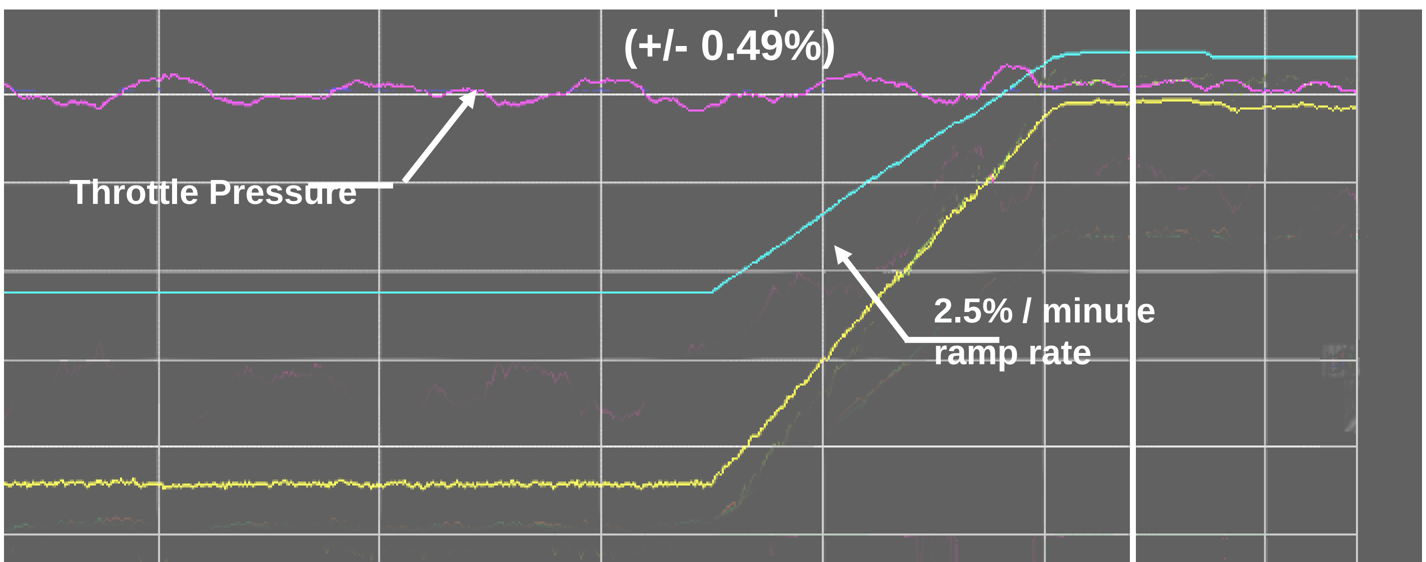
metso

Advanced Applications for Optimization



Objectives

1. Maintain boiler output to match demand requirements e.g. steam turbines, manufacturing process
2. Maintain boiler-turbine balance (throttle pressure)
3. Optimize for efficiency and emissions
4. Protect boiler from unsafe fuel air ratio

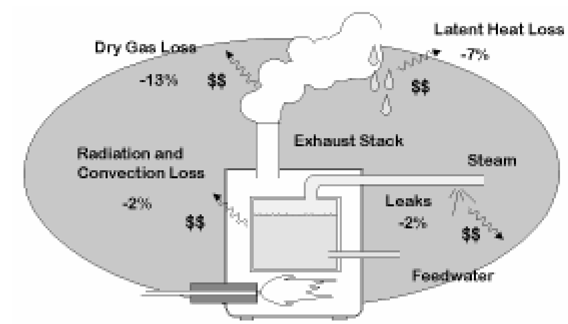


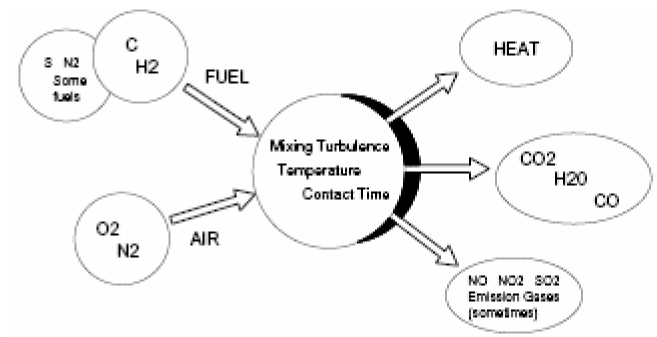
Before we optimize we need to test and do a ***Performance Enhancement Study***

- Every plant is unique and may require a different approach to optimizing the process
- A performance improvement study is needed to assess the achievable process improvement potential that can be translated into concrete savings and/or gains
- The performance study is usually accomplished in two phases:
  - Phase 1 – on site audit, typically 3-5 days
  - Phase 2 – data analysis phase, typical duration 2-4 weeks, depending on the complexity
- Detailed report provided to owner highlighting process improvement potential including commercial justification based on criteria set jointly with the customer

Performance Improvement Study: *Scope*

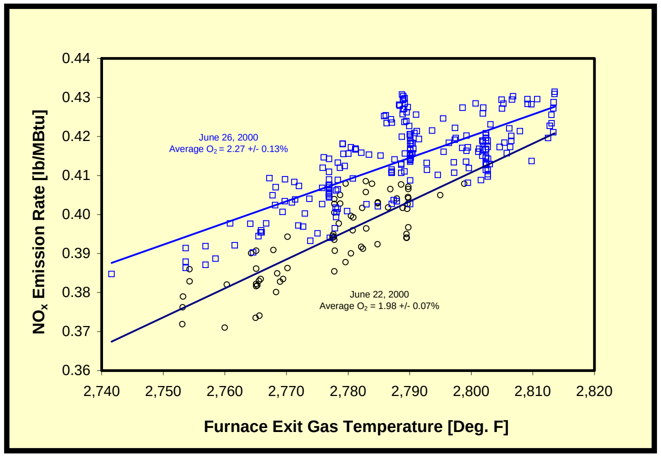
- Main emphasis – evaluate potential process improvement
- Determine feasibility and scope of optimization applications
- Process testing in conjunction with plant personnel
- Study Targets:
  - Benchmark current performance
  - Evaluate known issues and identify any new limitations
  - Analyze boiler upsets and identify sources
  - Evaluate benefits of advanced optimization applications
  - Evaluate benefits of advanced steam network controls
  - Review existing control strategy and propose enhancements
- Analyze data from the plant PI system

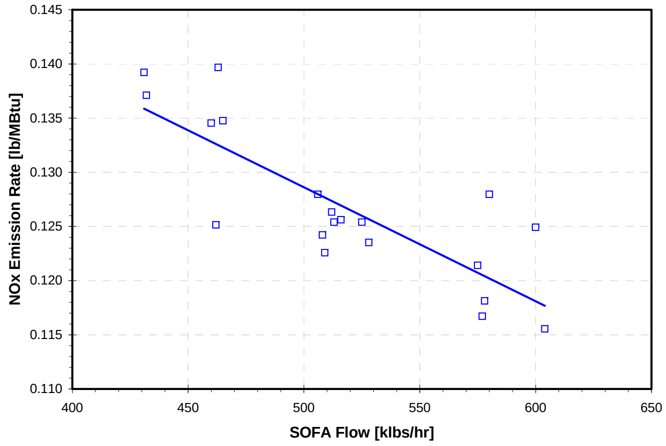




Performance Improvement Study: *Testing*

- Excess air , boiler leakage, emissions, etc. Oxygen Tests:
  - Relationships of O_2, CO, excess air
  - Control dynamics and response with regard to NOx, SO_x and other HAPs
- Undergrate air (primary air) and overfire air (secondary air) flow response tests:
  - Relationship of air distribution to other parameters such as furnace and back-end temperature, NOx, SO_x, opacity, etc.
  - Determination of minimum undergrate air and bed combustion stability
- Bed Inventory Tests:
  - Effect of bed inventory on the combustion profile is tested by modulating bed ash removal and/or grate speed
  - Relationships of bed height, primary air, combustion stability and furnace heat release

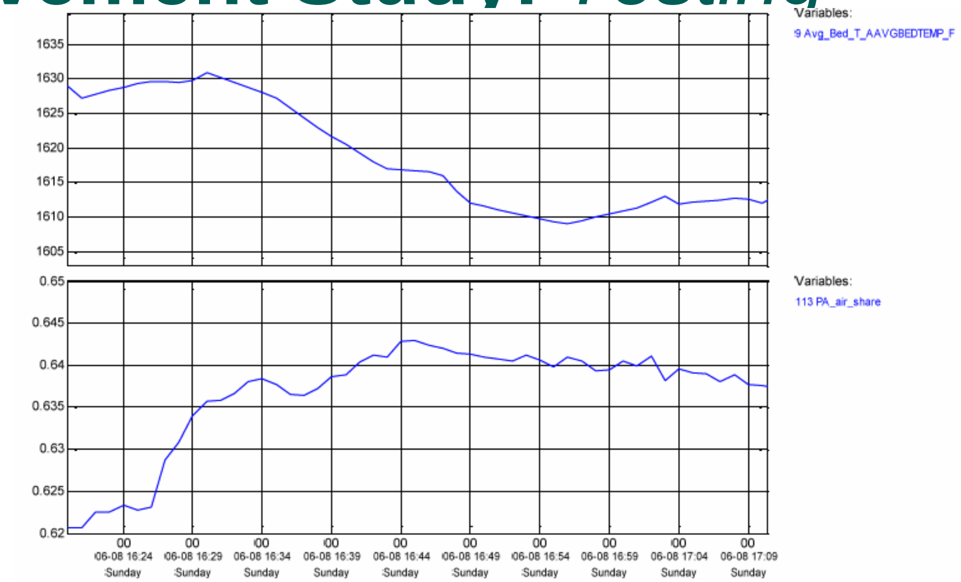


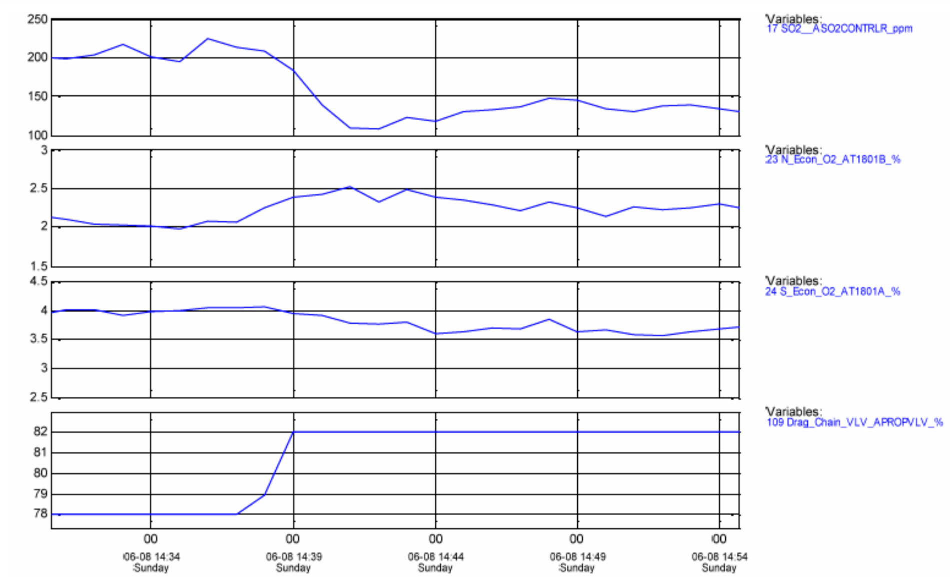


metso

Performance Improvement Study: *Testing*

- **Bed Temperature Tests**:
  - Bed temperature is raised/lowered approximately 50-100F by varying primary air. Flue gas oxygen is held constant.
  - The effect on steaming rate, NOx, CO and SO_2 emissions are observed along with control system performance
- **Fuel Feed Symmetry Tests**:
  - Fuel feed distribution is varied by biasing the demand to each feeder
  - Furnace temperature profiles are created.
  - The fuel feed distribution equipment is tested for linearity and repeatability.
  - Control system performance is observed

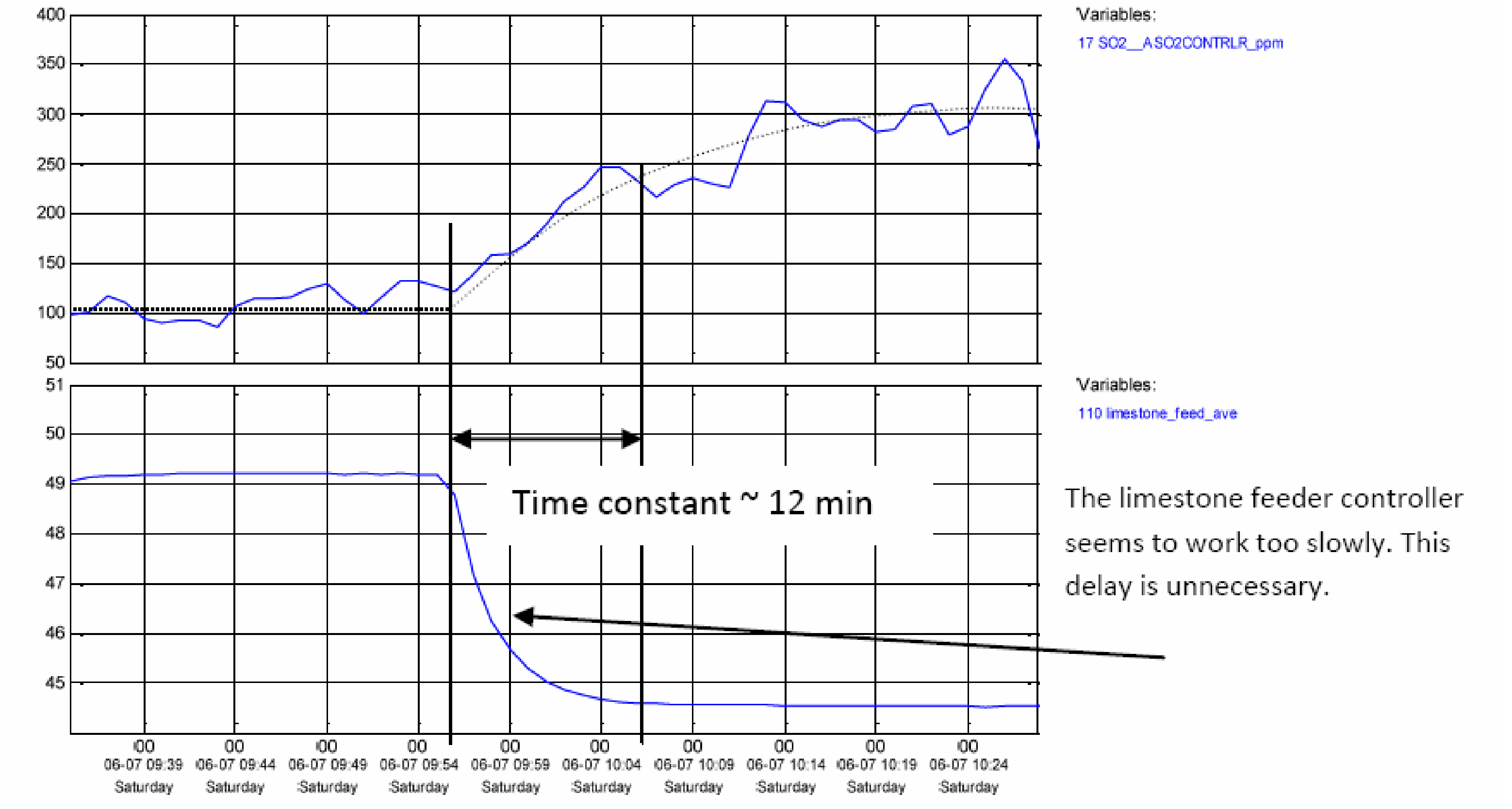




Performance Improvement Study: *Testing*

Limestone Feed Tests (coal fired FBC boiler only)

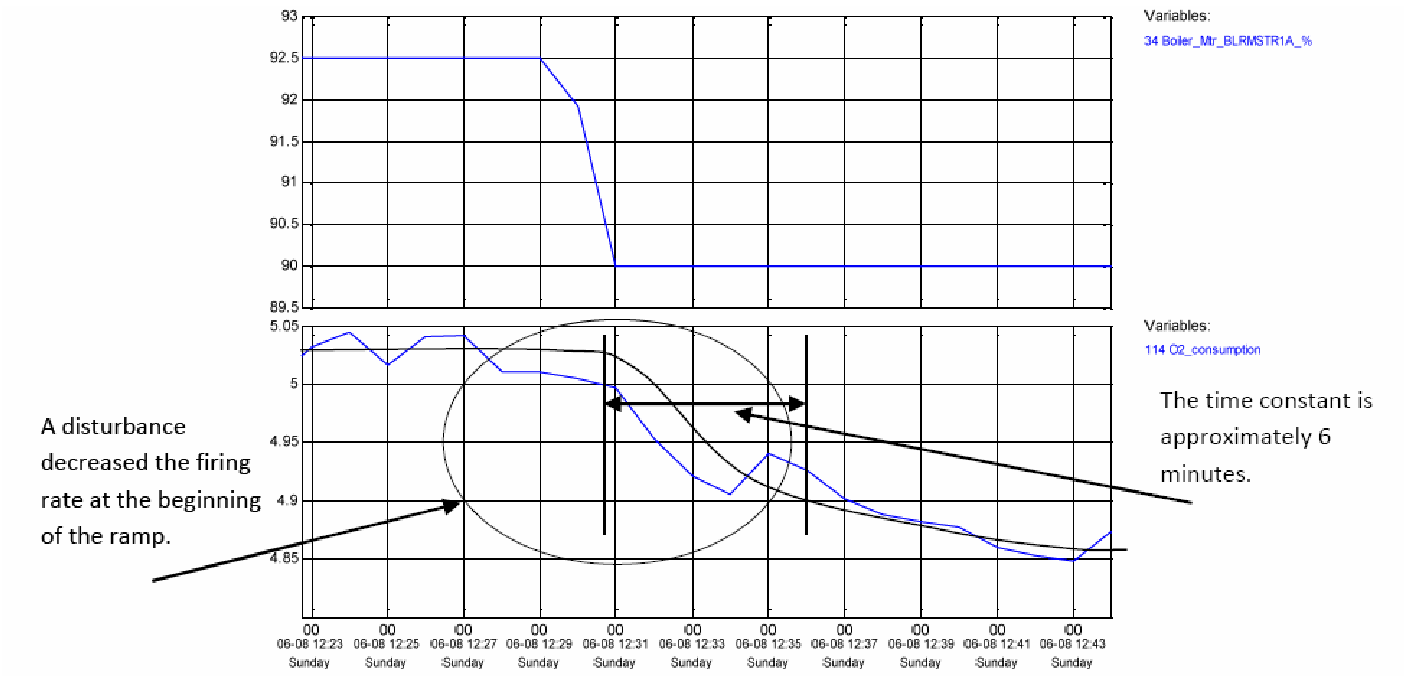
- Limestone feed is varied +/- 20% and returned to normal on an hourly basis
- Emissions are monitored e.g. SO_2, NOx, and CO
- Control system response is observed



The limestone feeder controller seems to work too slowly. This delay is unnecessary.

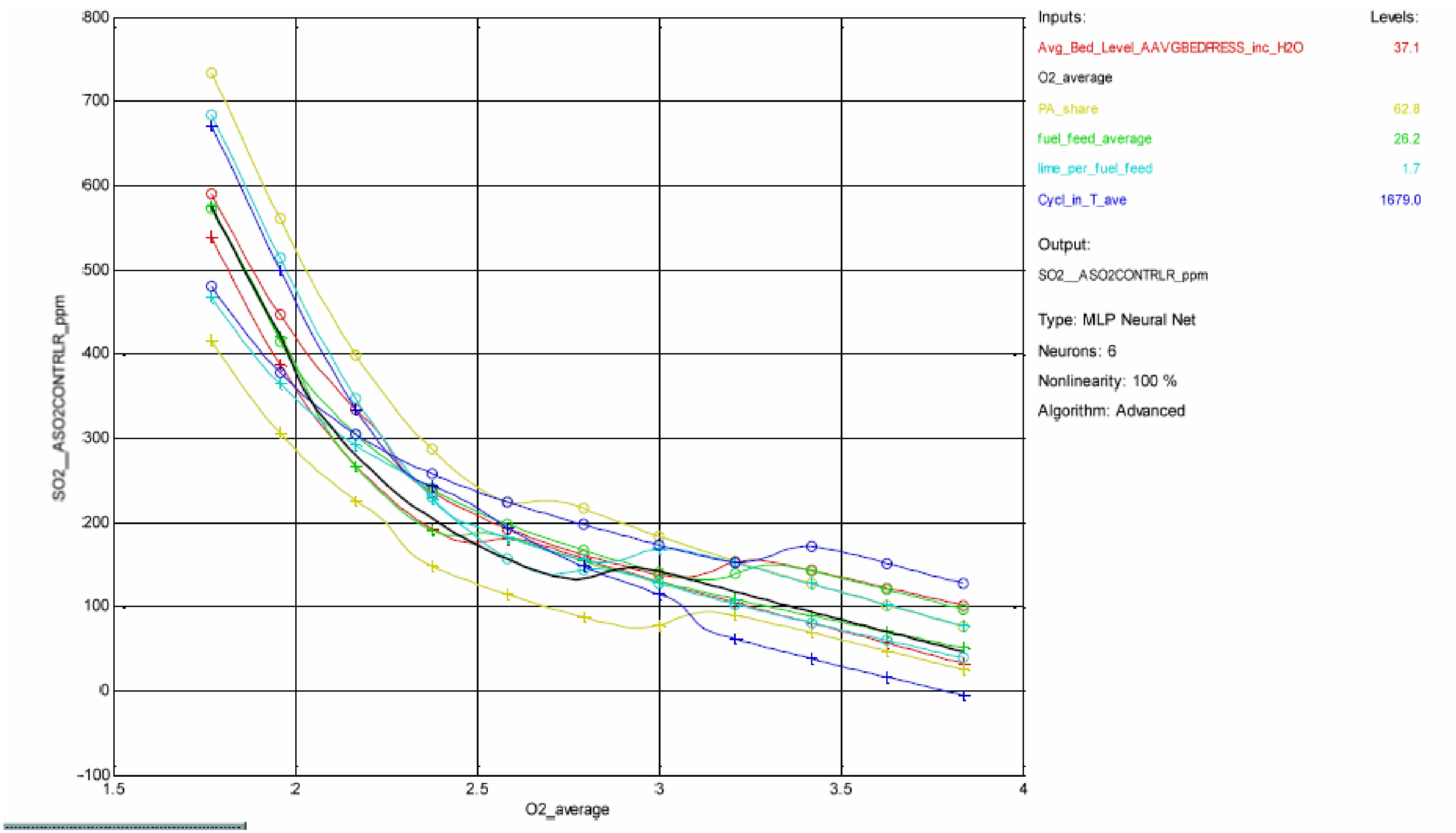
Performance Improvement Study: *Testing*

- Boiler Control Performance Tests: The performance of the boiler controls is tested by changing the boiler load at two different ramp rates, from nominal high load to a lower load and back.
- For the duration of the tests, it will be required to reduce load so that the changes in the process can be observed without constantly bumping into the top limit of the unit
- Access to plant operational data is required including but not limited to the following: Boiler and plant basic data such as capacity, basic design principles, fuel, ramp rates, control diagrams, P&I diagrams, I/O list and boiler layout.



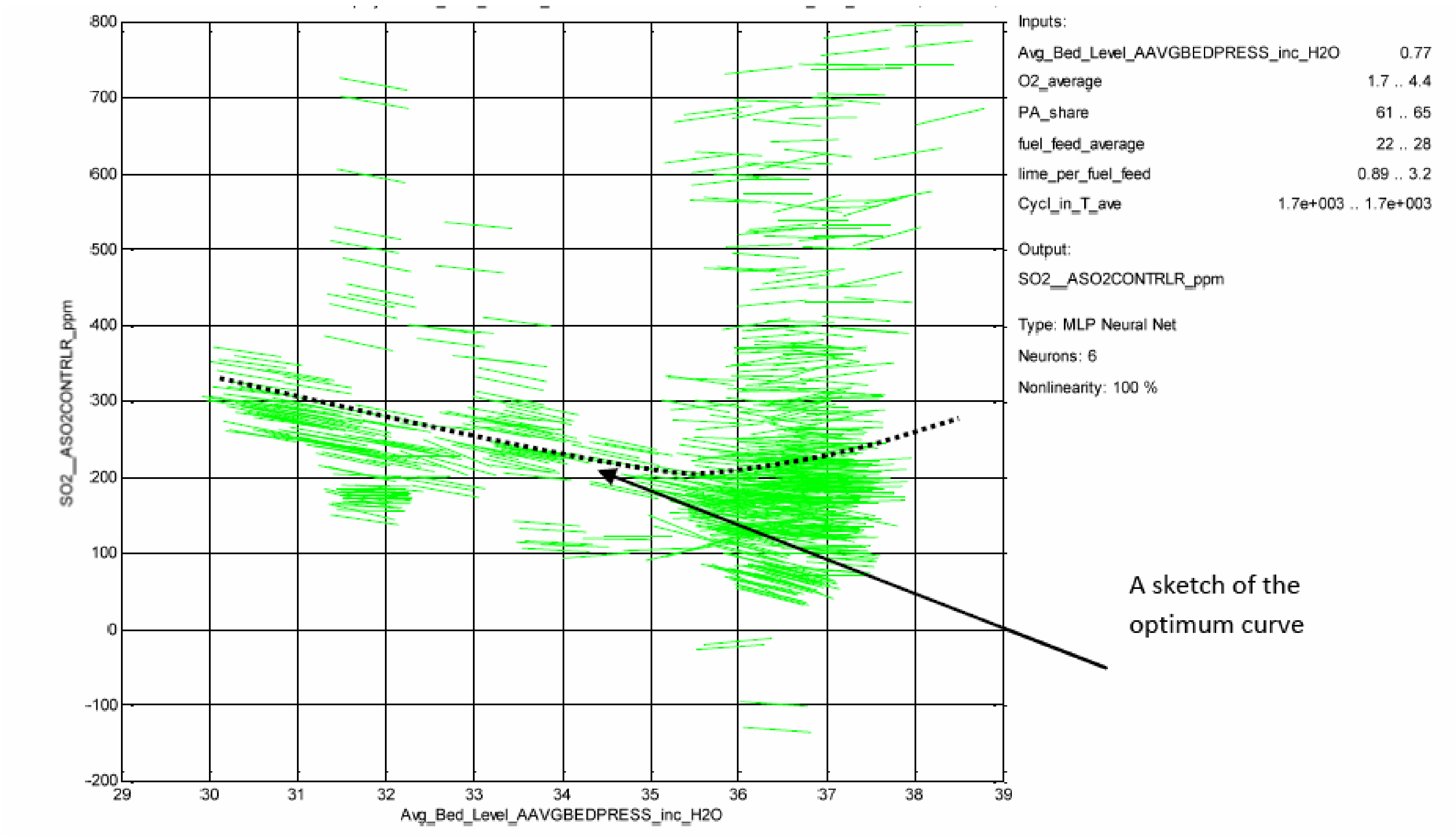
Performance Improvement Study: *Simulation*

- Oxygen levels vs SO_2



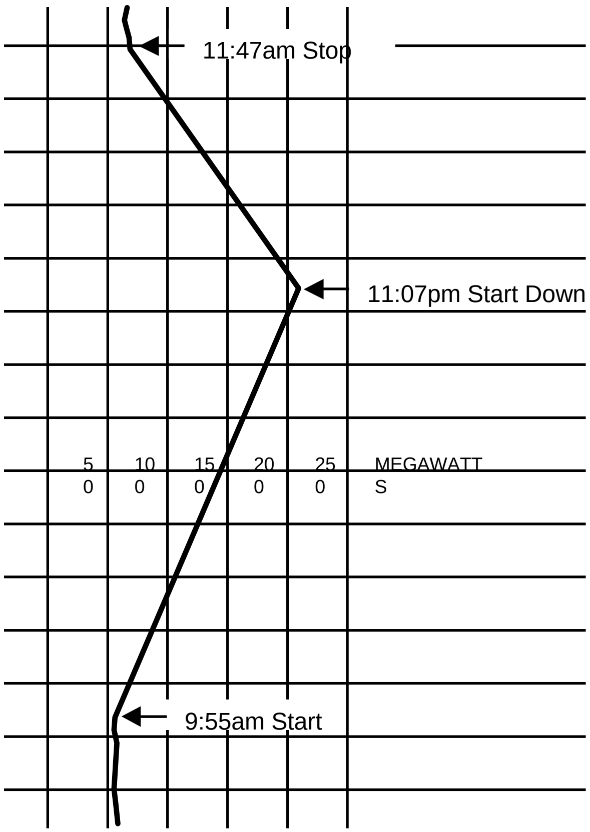
Performance Improvement Study: *Modeling*

- **For the boiler in question the optimum bed level is about 35” WC.**



Meeting Objective 1… match generation (energy out) with demand

- ADS interface – *pulses or serial link*
- Operator interface – *set limits, rate, target*
- Frequency bias – *equal to and opposite polarity of governor*
- MW control w/ feedforward
- Turbine 1st stage pressure – *fast responding cascade loop*
- Blocks and over-rides from constraint coordinator and DLR
- **Turbine follow mode option – *use only in runback mode***



Meets objective 1!

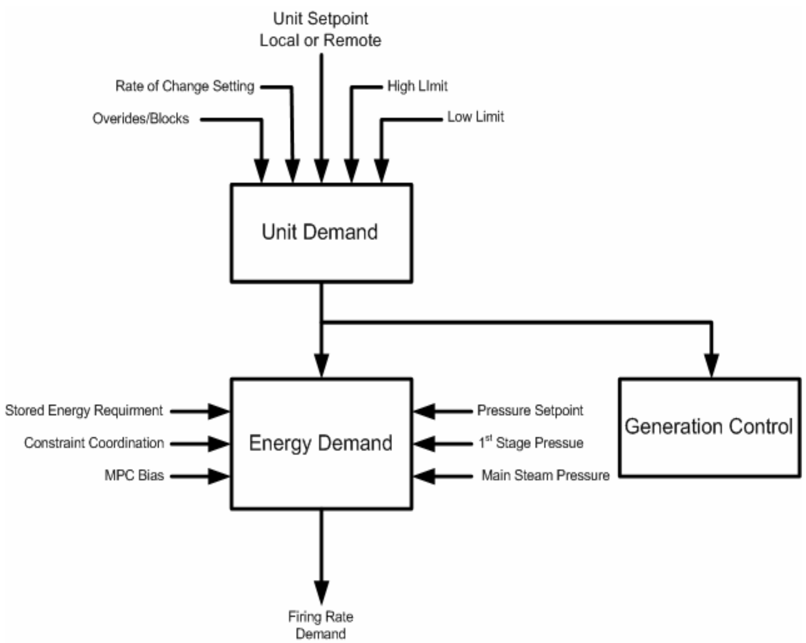
metso

Meet Objective 2 – *maintain boiler turbine balance i.e. main steam pressure*

Must compute the energy demand for boiler(s)…

- Must be a function of energy requirement of steam host (turbine and/or process)
- Must be real time calculation
- Must account for precise over/under firing
- Must not be affected by change in fuel quality or disturbances in boiler

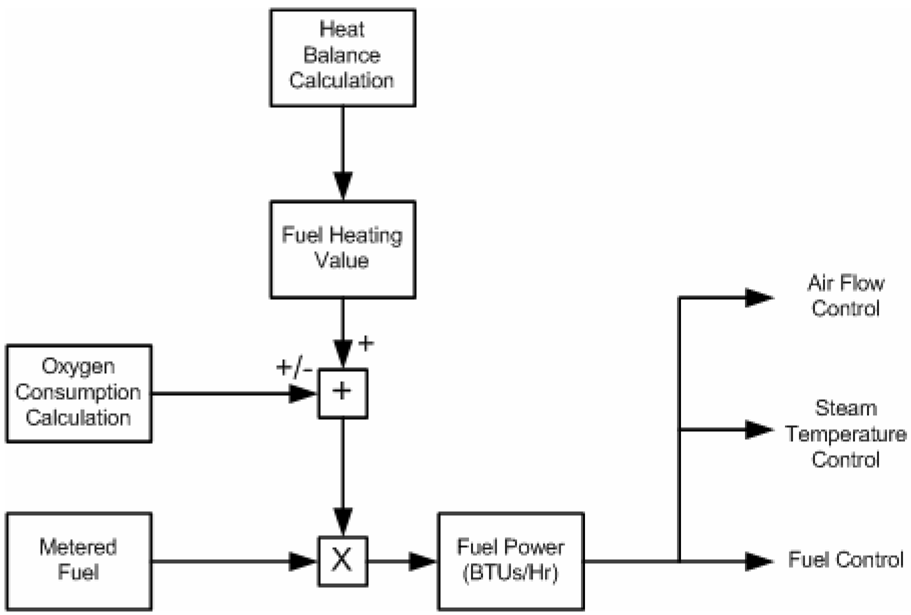
Not directly calculated from steam flow!



Must calculate true energy input i.e. *heat release*

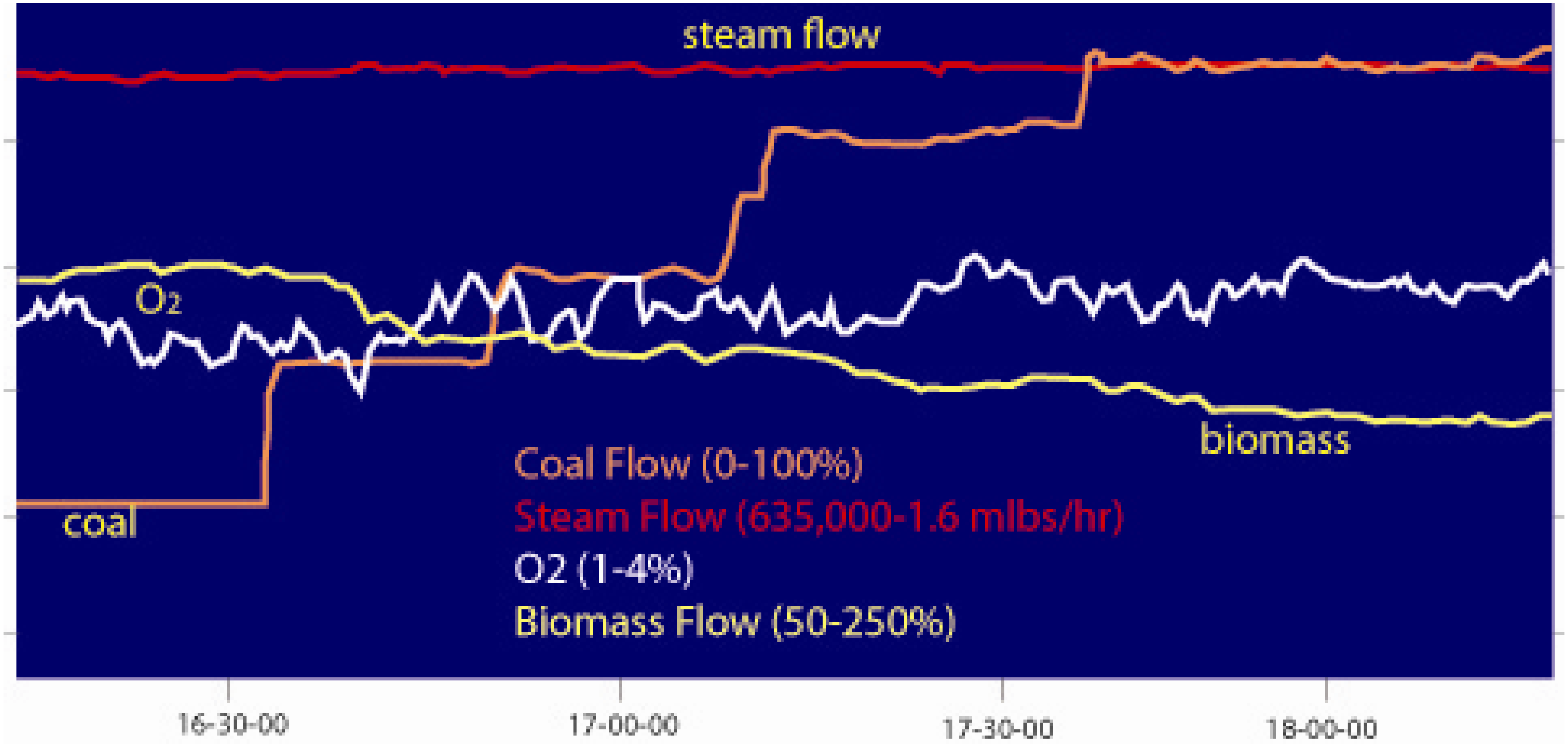
Methods based upon the type of combustion system…

- Must deal with changing fuel quality, density, moisture, etc.
- Must be a real time calculation
- Must be correct under all circumstances



Fuel Power Compensator results on a 240MWe coal and biomass unit

Coal is being increased manually in 15% steps. Fuel control is automatically responding to increased heat release by driving the biomass downward to maintain constant energy out



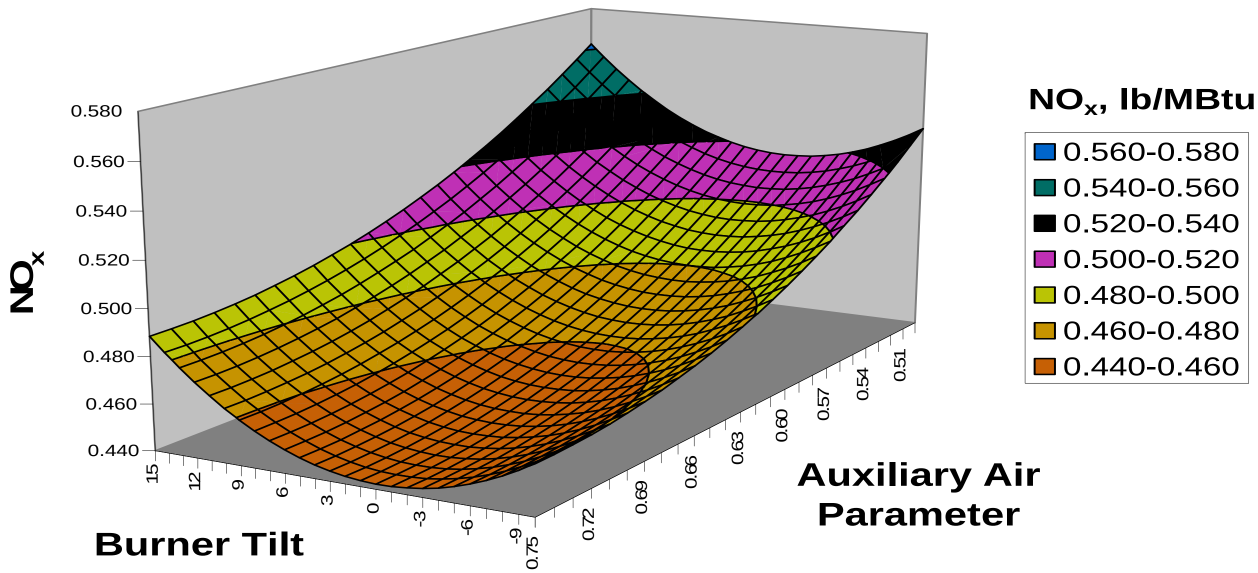
Meet Objective 3 - Combustion Optimization

"Modifications to the boiler control settings to achieve a particular objective (target emission level) with minimum heat rate penalty, subject to operational and/or environmental constraints."

metso

Optimizing combustion for efficiency and emissions

- Optimization is a trade-off between emissions and efficiency
- Process is not that easy to model
- Must include operating experience
- Must be easy to upgrade and maintain



Combustion Optimizer:

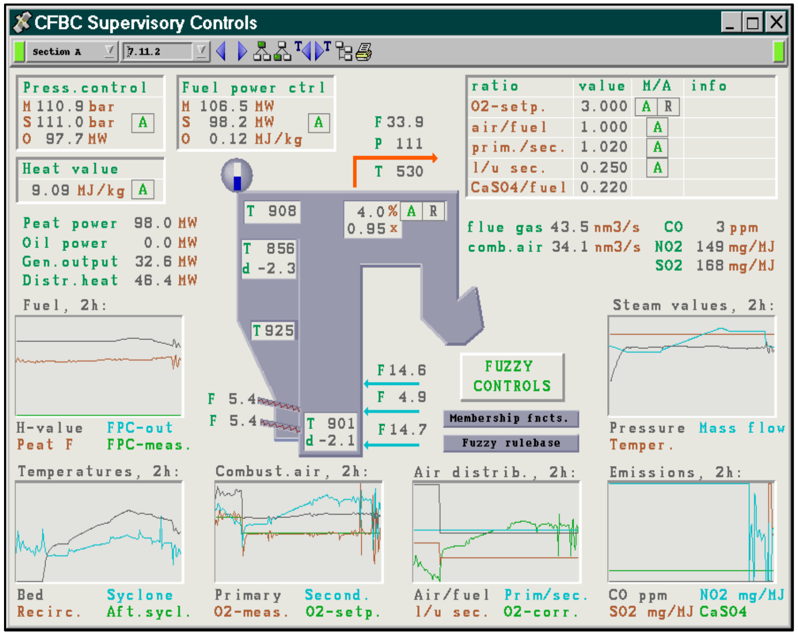
What is a combustion optimizer ?

The combustion optimizer is an advanced supervisory application for optimized combustion

How does it work?

The backbone of the combustion optimizer is a set of multivariable fuzzy controllers regulating several combustion variables such as:

- Bed level inventory
- Furnace temperature profile
- Cyclone inlet temperatures
- Primary/Secondary air distribution
- Fuel feed, limestone feed & ammonia feed
- Flue gas oxygen content
- NOx/CO, SO_2 optimization

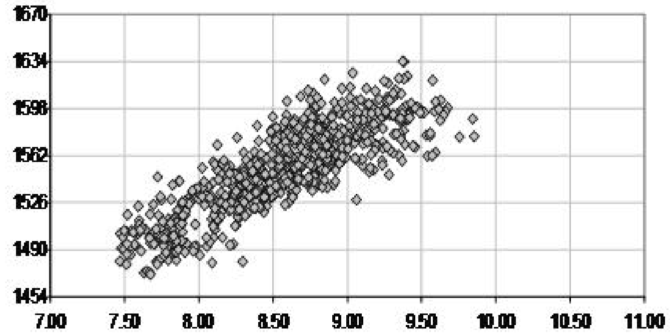


Combustion Optimizer:

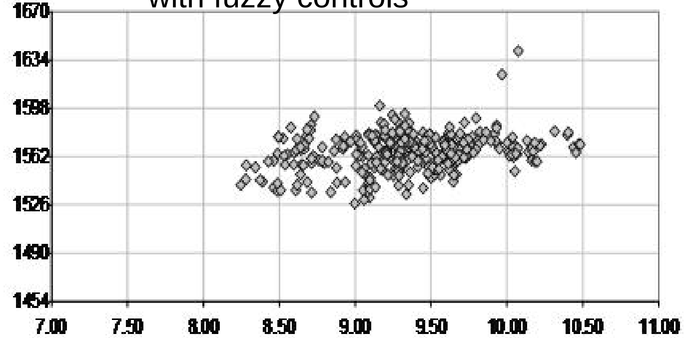
Results:

- The combustion proces is stabilized
- Simple and steady boiler operation
- Improved boiler efficiency
- Decreased bed temperature variation
- Minimized LOI carbon
- Minimized flue gas oxygen content
- Optimized limestone use
- Minimized SO_2, NOx and CO emissions
- Enhanced environmental compliance
- Accurate estimation of fuel btu in real time. Enables the use of mixed fuels

Bed temperature variation
with traditional controls



Bed temperature variation
with fuzzy controls



Fuzzy Logic Optimization:

Why fuzzy logic based optimization system?

Real world processes are often non-linear and difficult to model

A seemingly simple process can require multiple sets of differential equations to model

Processes have strong cross influences

Fuzzy logic based control is the answer-

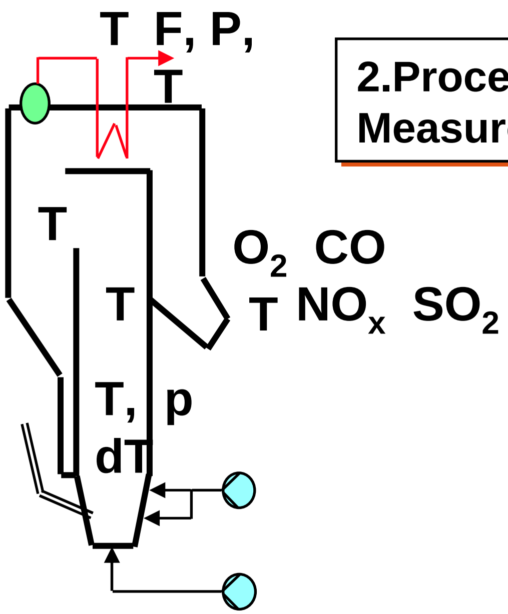
Unlike other optimization packages, Fuzzy logic controls are NOT self learning

The benefit is that -

- The Fuzzy controls can be defined after a short **performance improvement study**
- Fuzzy controls can incorporate months or even years of data into the design
- A unique property of a fuzzy based system is that operator knowledge can be utilized
- Fuzzy logic is transparent, not a black box i.e. the logic is based on linguistic rules
- Each controller looks at multiple process measurements

metso

Fuzzy Controls Basic Structure:



2.Process Measurements

3. Operator know-how

Fuzzy-logic

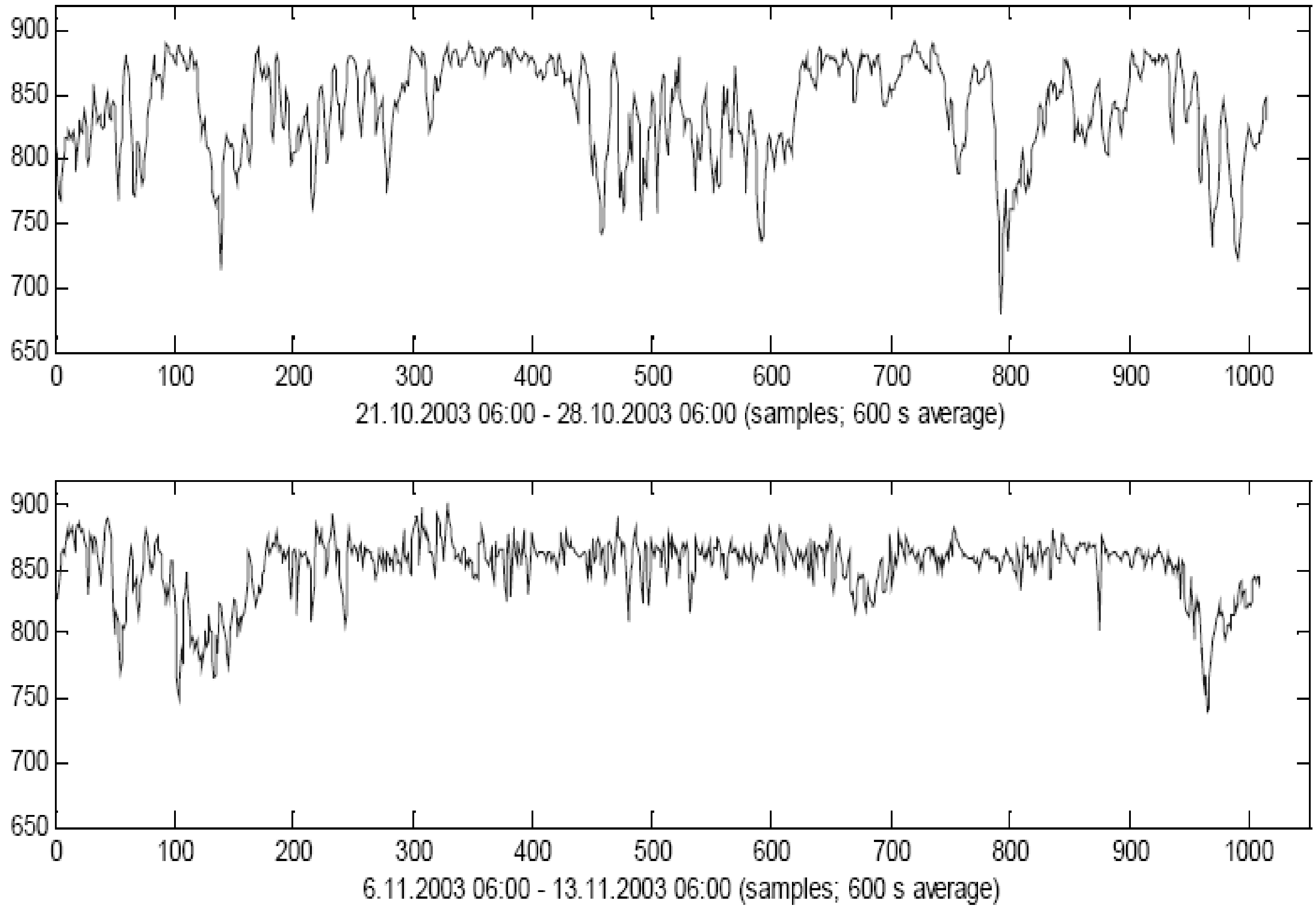
(control/ Compensation/ Filtering / Recipe)

1. Calculated variables
- fuel heating value
- oxygen consumption
- flue gas flow
- emissions mg/MJ

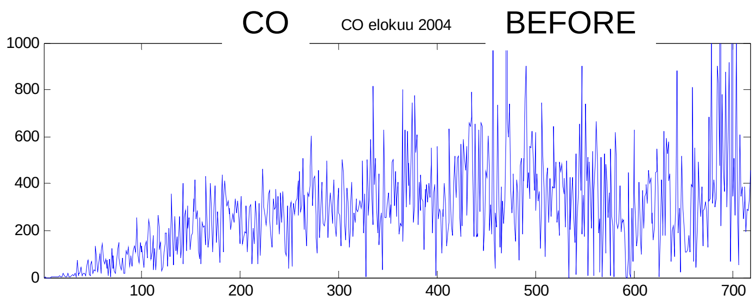
Tuning parameters
- fuel/air setpoints
- prim./sec. air setpoints
- lower/upper sec. air
- O_2-controller setpoint
- fuel distribution

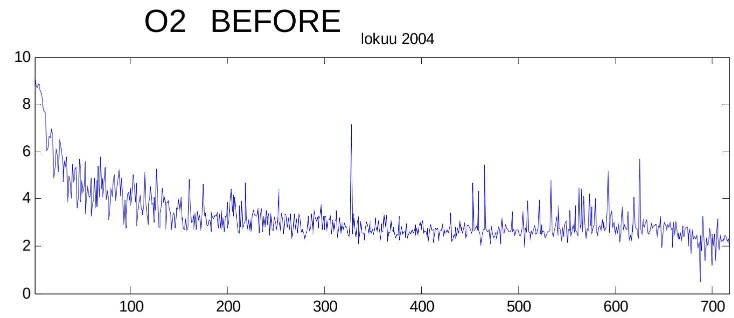
•Limestone/ammonia feeder setpoint

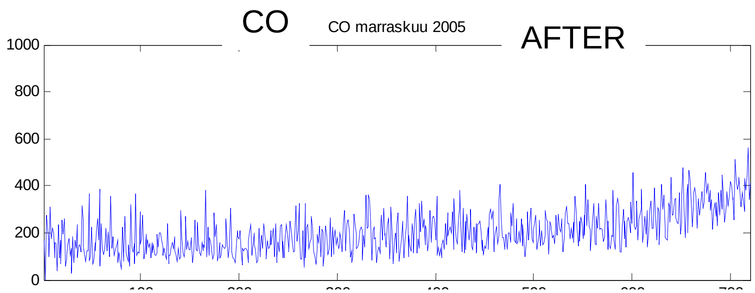
Bed Temperature before (upper chart) and after optimization (lower Chart)…

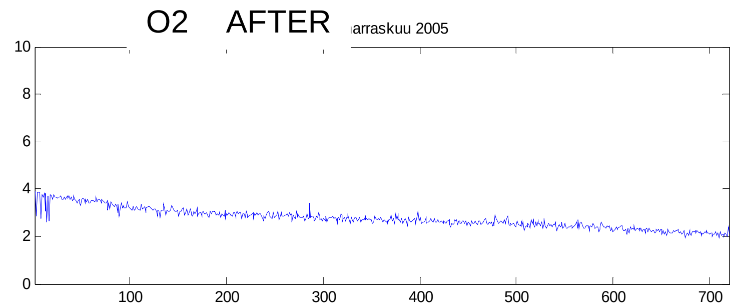


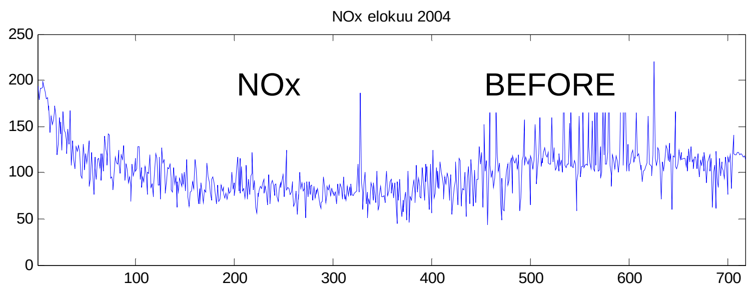
Combustion Optimization on BFB firing biomass mixture

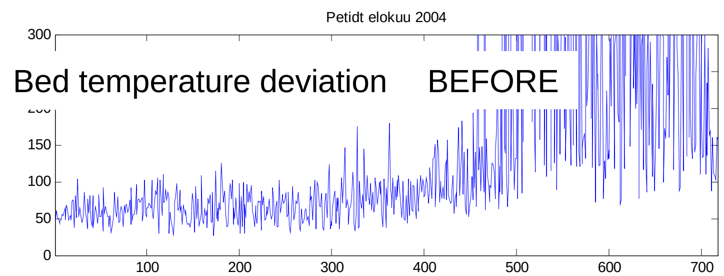


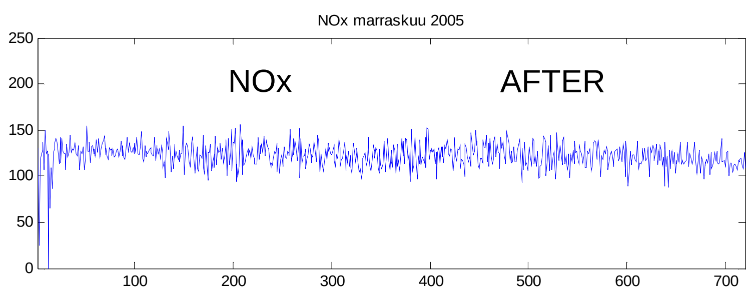


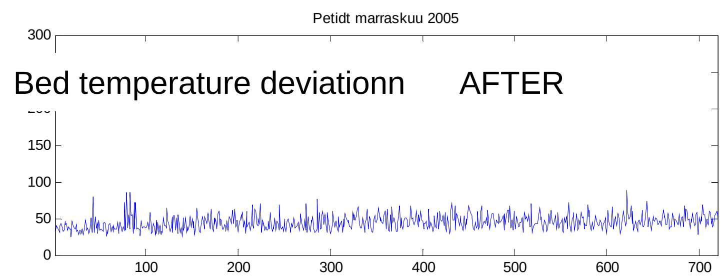






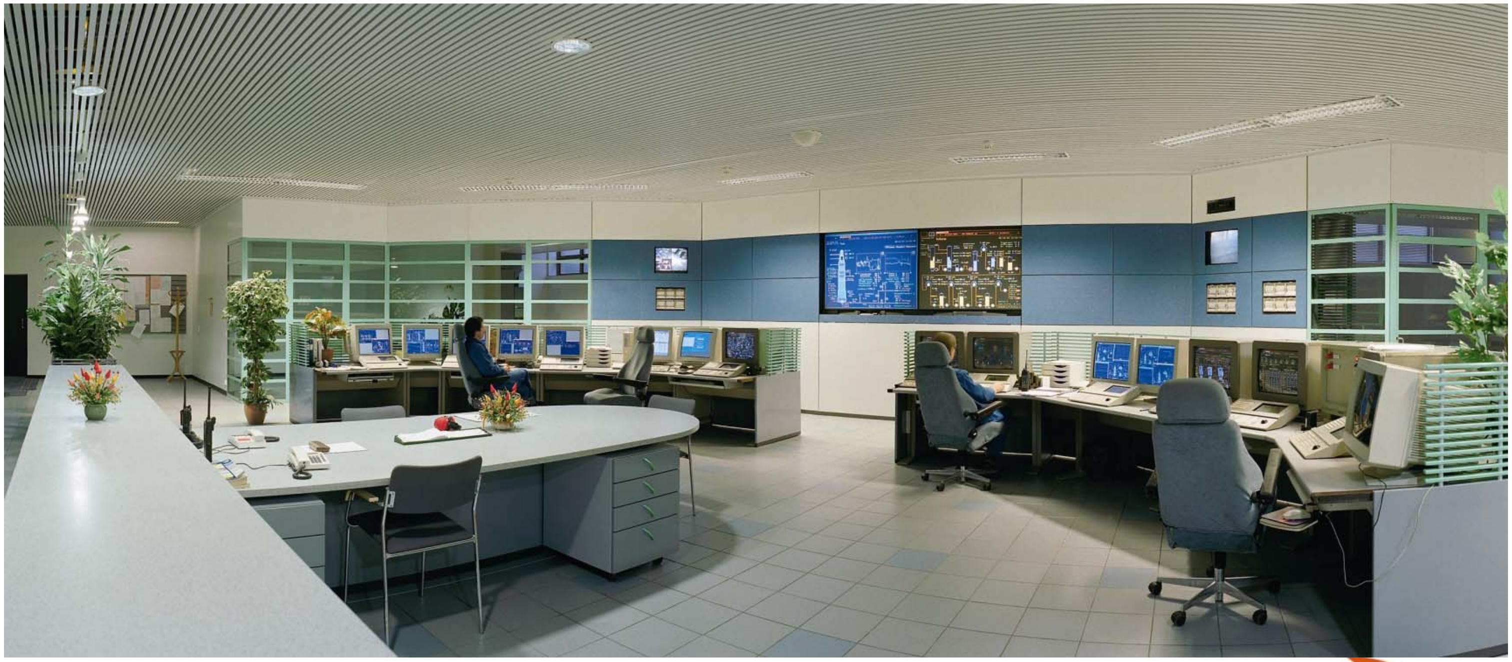






Optimizing the plant… *A new approach*

- **Plant operators need help** - *a team of experts with the ability to provide them with timely information is needed to optimize operations.*
- **The control system has changed** – *now a supervisory system*
- **Plant functions are integrated –** *operations, maintenance and management have the same information at their command*
- **The new control room** - *center for exchange of ideas and solutions*



metso

The evolution of process control reflects the requirements set by operational organizations.

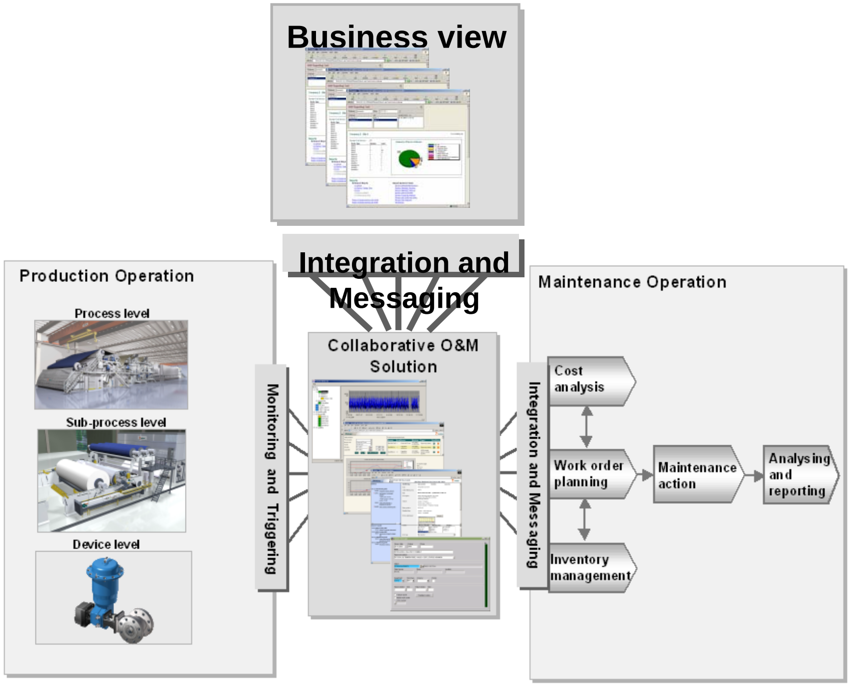
The parallel development of user interfaces, information systems and the decision making process has produced new requirements…

- Tools to exchange expertise and knowledge in a timely fashion shall be an integral part of the system
- Facilities to enable experts in remote locations to cooperate and participate in the decision making process.
- **“Network-enabled cooperative groups”** whose information is gathered from private computer activities can be available at a moments notice.

A virtual network of “remote located” experts whose objectives are those of the management will be supported by future automation systems.

metso

Collaborative Interaction - A virtual network of “remote located” experts provide support

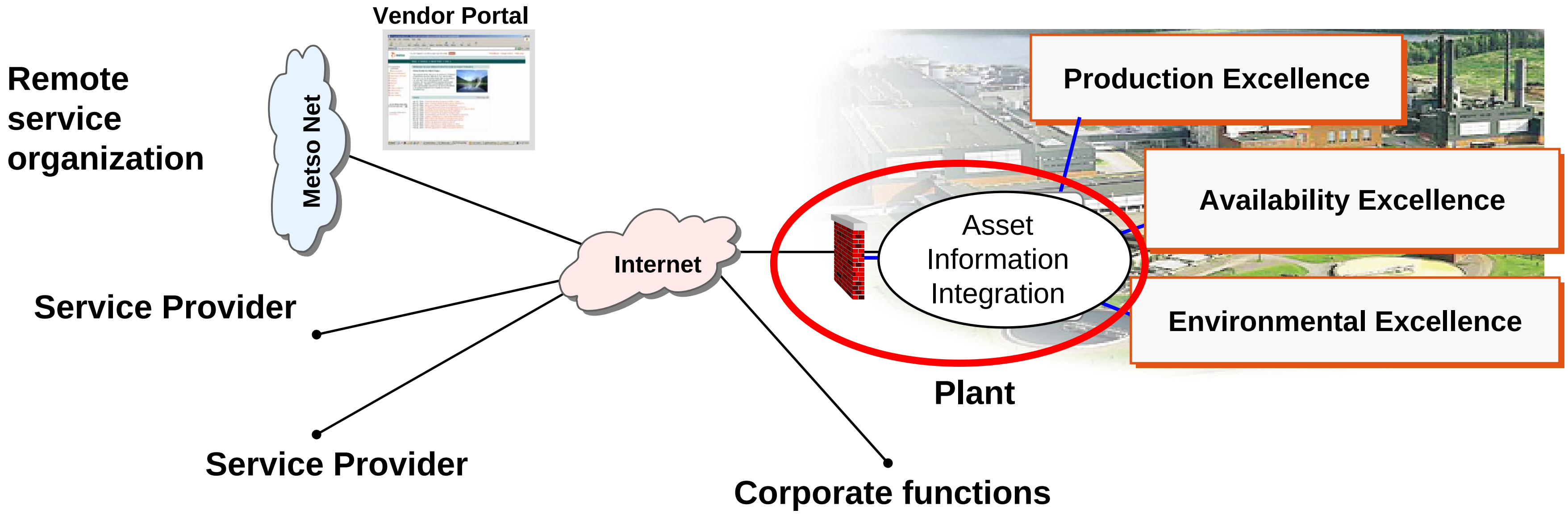


System portals allow experts to open Asset Management windows which promotes better decision making, faster response and increased management awareness.

- “Collaboration management” – team of local and remote specialists with same objectives are networked to access the same data
- System tools automatically integrate current process data with historical trends and relevant events and alarms

metso

Experts include 3rd party consultants



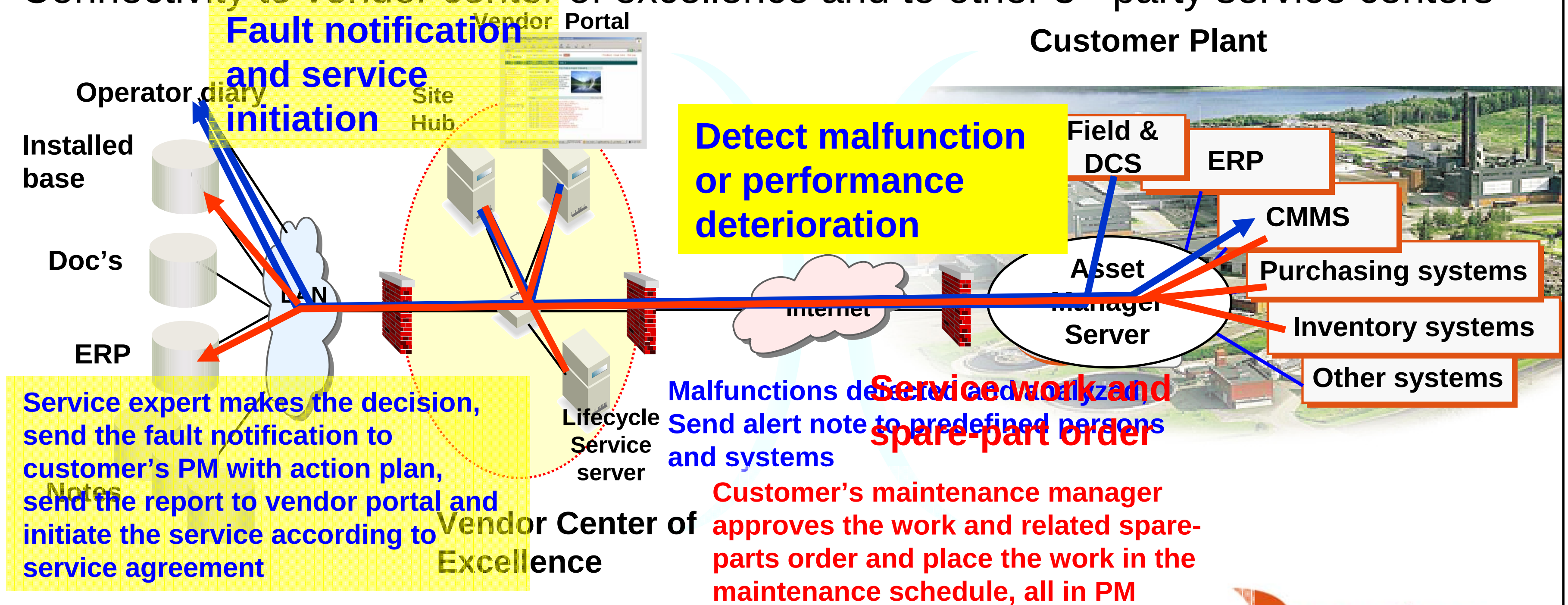
- The automation system is a platform to support many different application programs obtained from the outside community.
- It becomes less a control system and more a recipient for supervisory optimization and information transfer.

Automation platforms need to be open for all to use, improve and integrate.

Bringing the experts to the process

System facilitates predictive and condition-based maintenance and collaborative maintenance management at the plant

- Information security must be guaranteed
- Easily manageable messaging system
- Connectivity adapters to plant systems
- Connectivity to vendor center of excellence and to other 3rd party service centers



Summary

- Need to do a study first and determine base line and what can be achieved
- Focus on 5 things:
  - Output (generation, energy flow) modulation - *linearize governor valves*
  - Unit rate of change - *including constraints*
  - Intelligence from the process system (steam client) – *direct interface to the final process control system*
  - Boiler /turbine balance – *true heat release calculation*
  - Emissions and efficiency – *a trade-off*
- Optimization of a complex process requires advanced applications e.g*. fuzzy logic control*
- Systems must allow for virtually unlimited connectivity so that owners can take advantage of the best in class software, instrumentation and expertise.

metso