Energy Efficiency Opportunities through Combustion Optimization

CIBO Fluidized Bed Combustion & Stoker Fired Boiler Operations and Performance Conference

David Eapen

Valmet

Outline

Combustion Optimization	• What is it? & • Why does it matter?
Technology	• What's under the hood?
Recent Case	• Review results from cases around the world
Summary	• What's the take home message?

Valmet

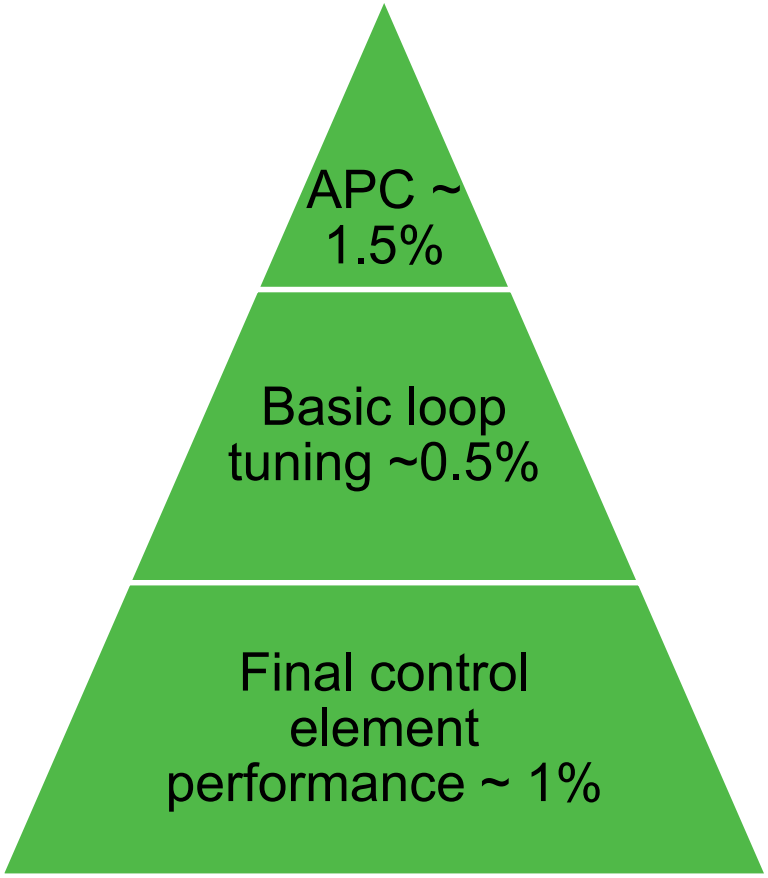
Everybody has it, but most of us rarely talk about it

- What am I talking about here?
- It's your boiler Control System
  - Typically, 10 – 35% of loops are in manual
  - 85% have incorrect tuning parameters
  - Operators "truck drive" the boiler
- The reasons are simple
  - The process has changed but the controls haven't kept up
  - PID's fail when it comes to non-linear, large dead time processes

Valmet

What do we mean by combustion optimization?

- **Step 1 - Automating the control loops**
  - Review the major control loops
  - Identify loops in manual
  - Modify loops followed by tuning to ensure automatic control
- **Step 2 – Implementing Advanced Process Control (APC)**
  - Identify loops with non-linear processes, variable dead times, critical constraints
  - Implement fuzzy logic or model predictive control based APC's
  - APC's provide setpoints to base loops or directly write to final control elements

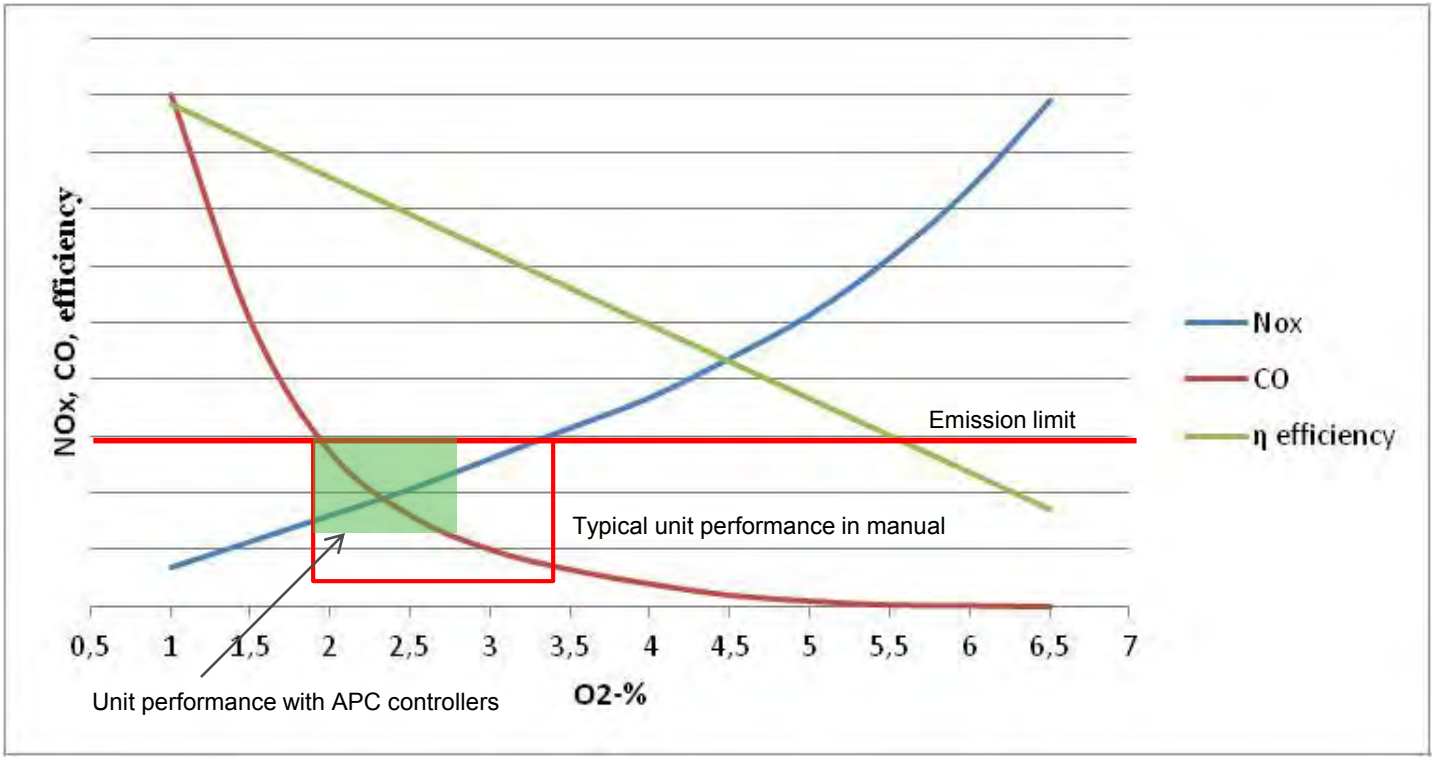


Savings as a percentage of operating costs

Brisk M.L, Process Control: Potential Benefits and Wasted Opportunities

How does it help efficiency?

Seeking optimum O2 setpoint and air distribution for continuously changing fuel quality – minimum emissions with maximum efficiency



Valmet

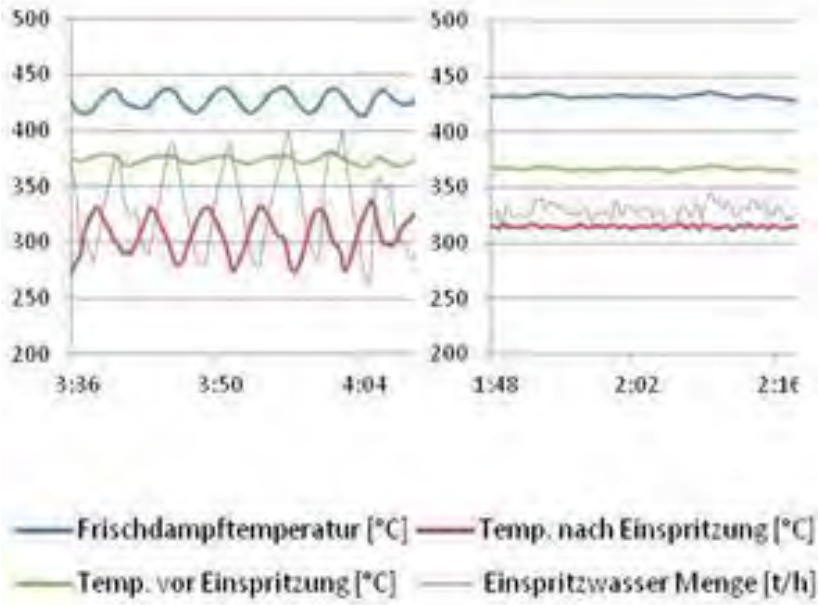
Examples of real cases from around the world

- Improvements in unit heat rate (thermal efficiency up by 1-2%)
- Reduction in emissions
  (CO 67% ↓, NO_x 30% ↓)
- Reduction in reagent use such as limestone and ammonia (13% ↓)
- Increased steam output and generation
- Improved steam temperature and pressure control
- Operational uniformity across shifts

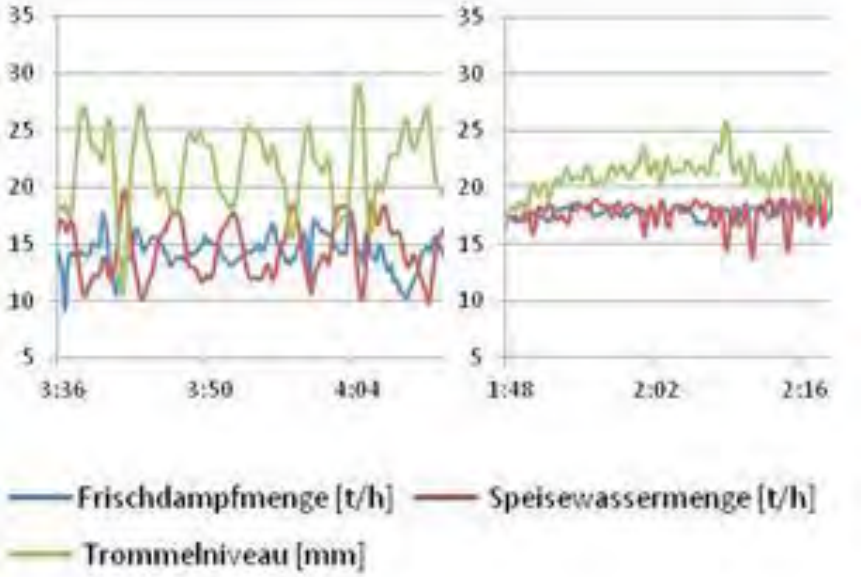
Valmet

Automating base controls & enhancing where possible

Live steam temperature



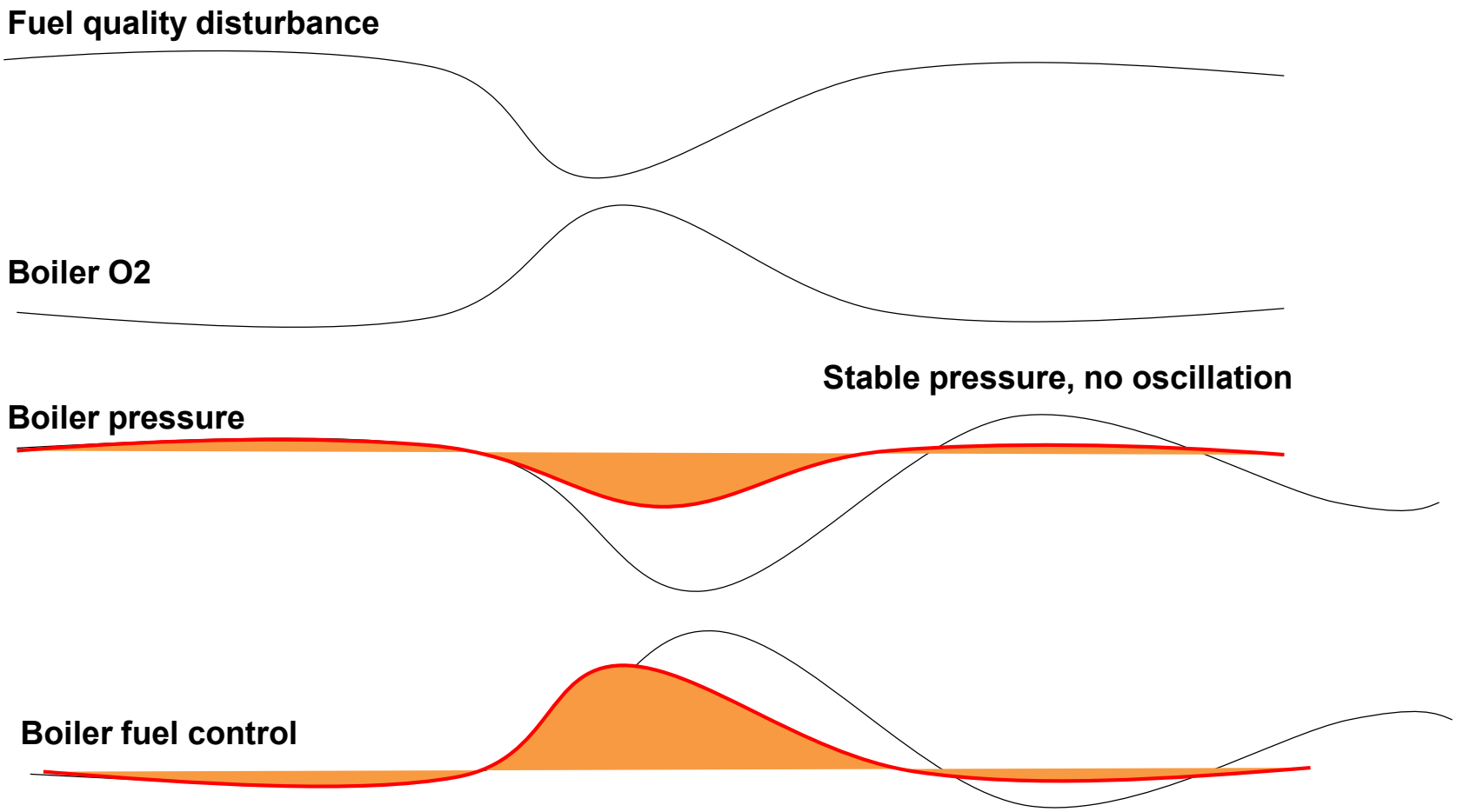
Boiler drum level



Valmet

Real time fuel btu compensation

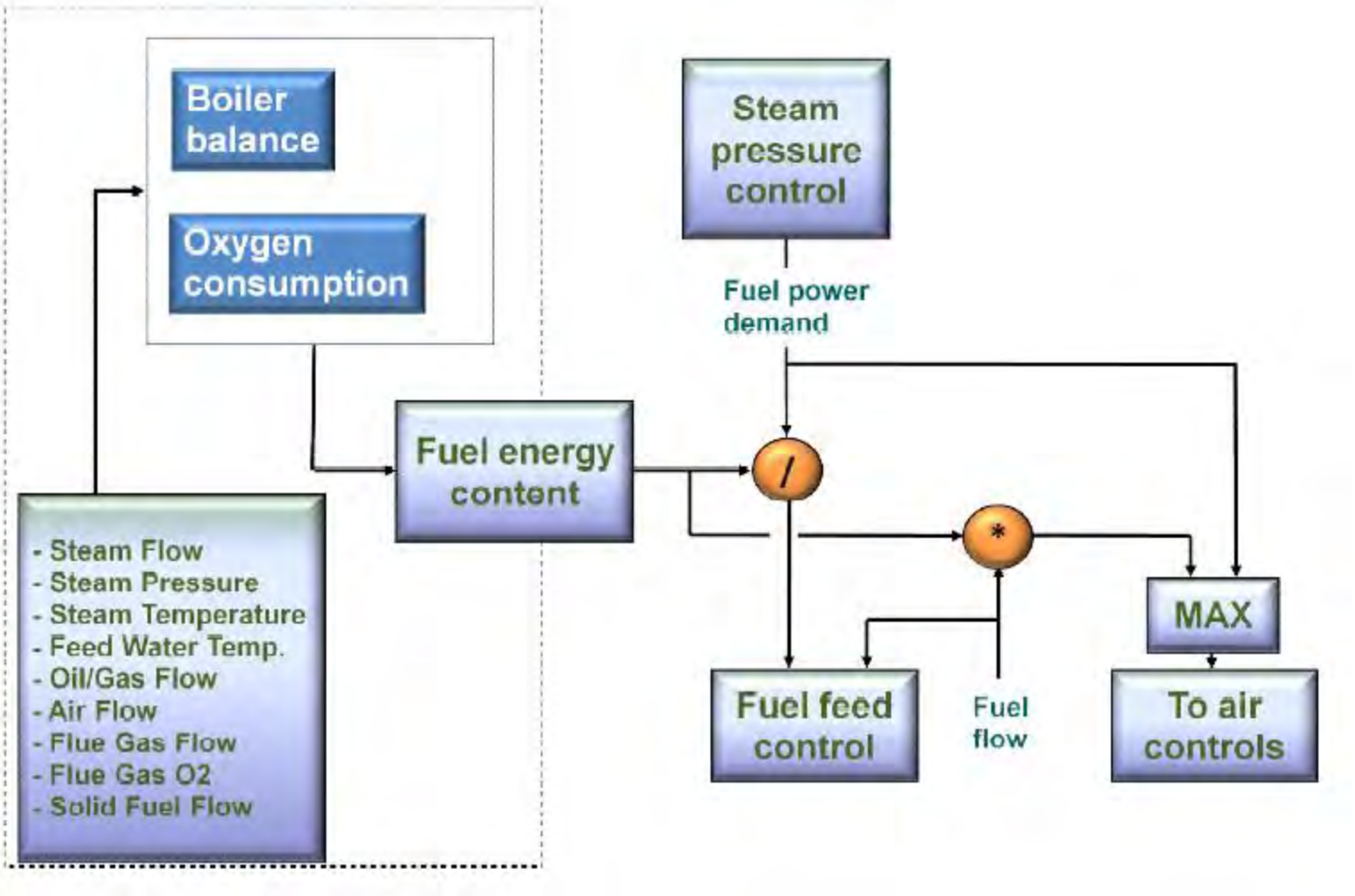
Real time fuel btu compensation



BTU Compensators should include the O_2 consumption

Valmet

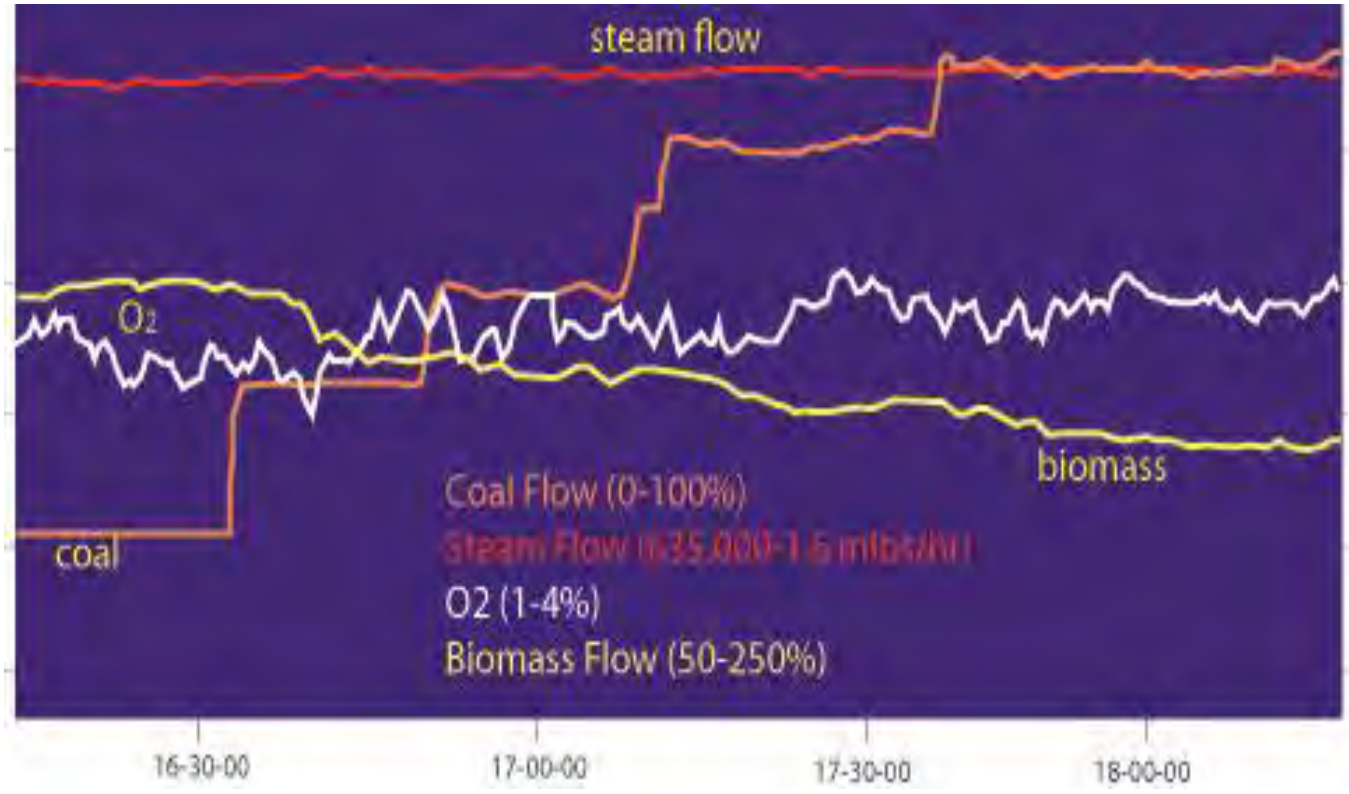
BTU Compensation input variables

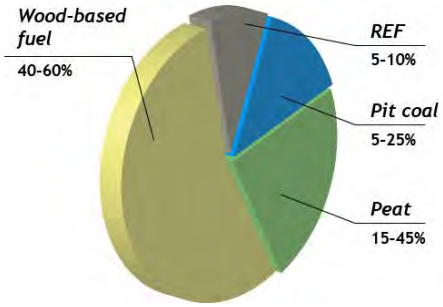


Valmet

Performance at Alholmens 240MWe CFB plant

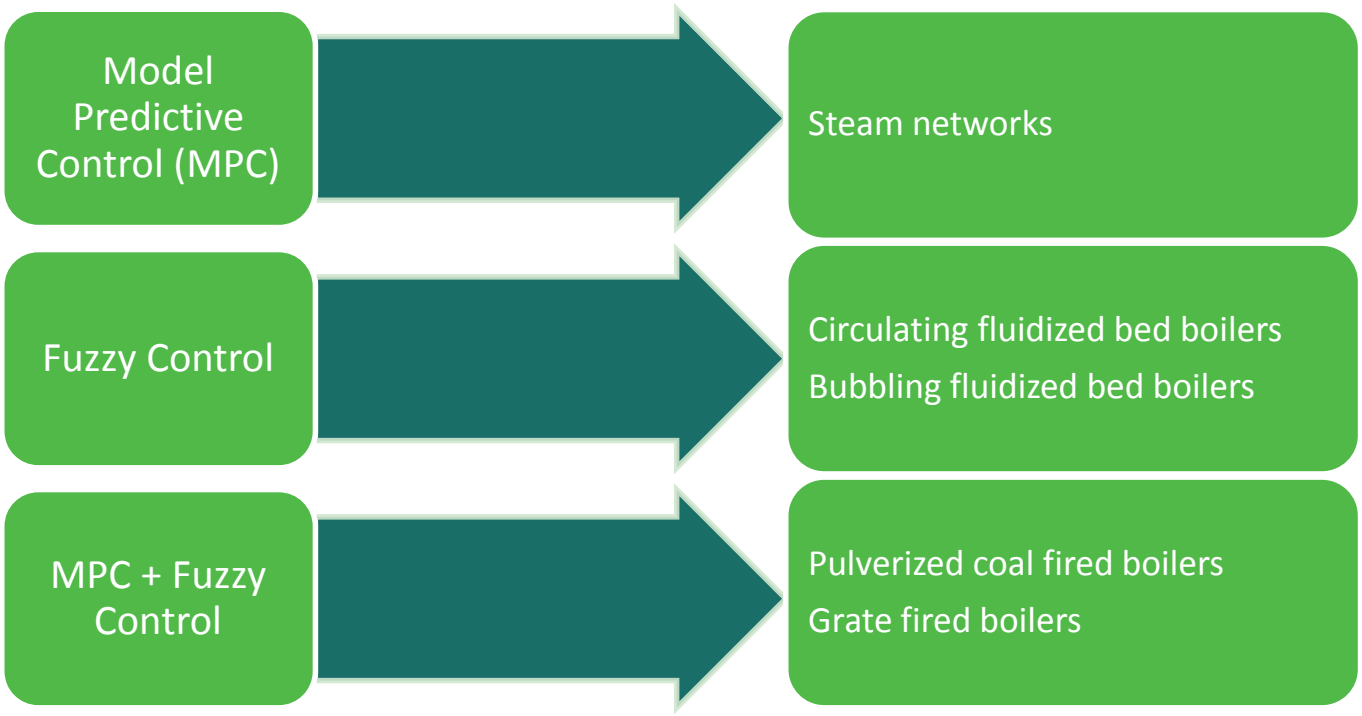
- Coal increased manually in 15% steps. Fuel control is automatically responding to increased heat release by driving the biomass downward to maintain constant energy out





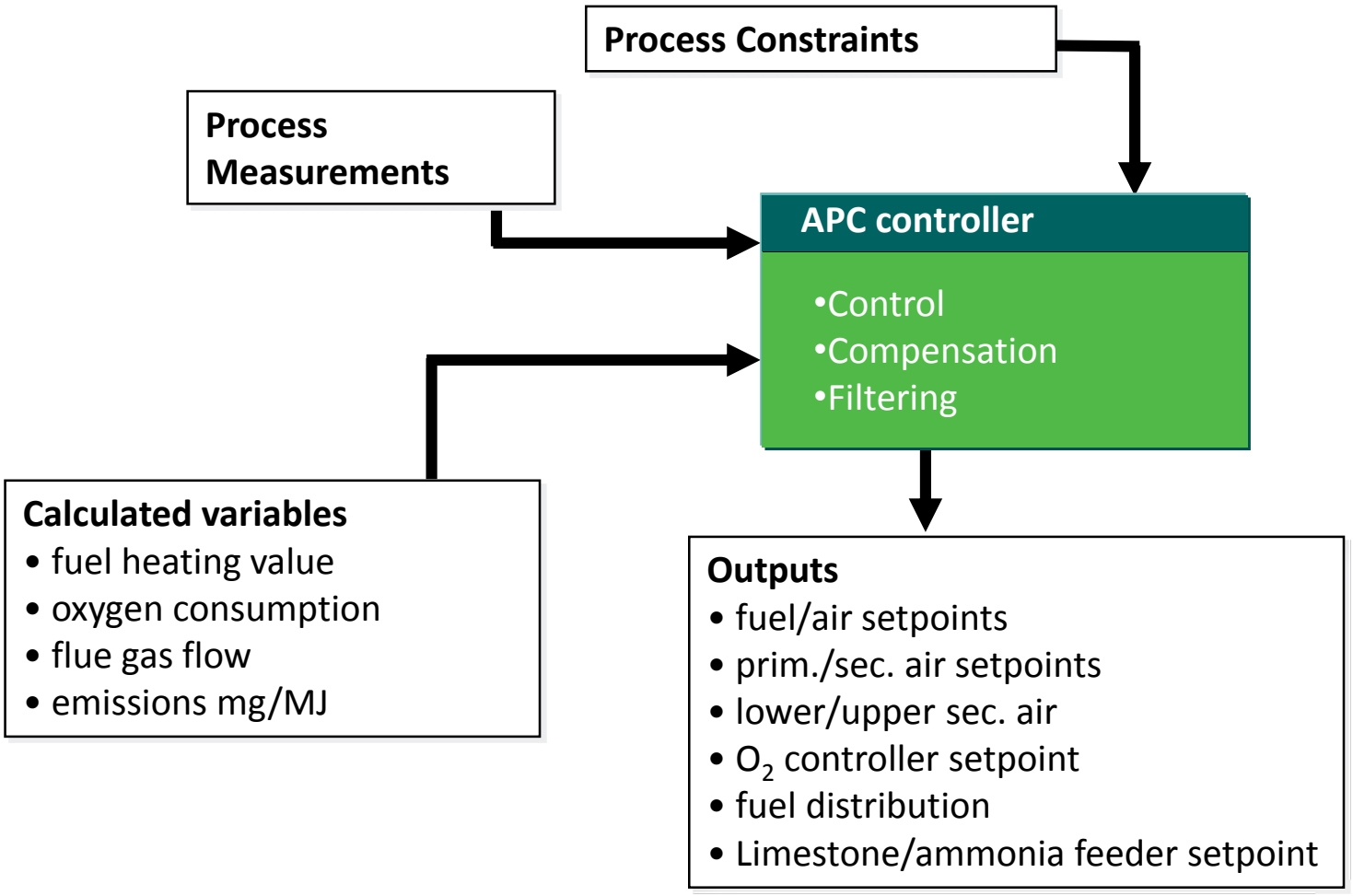
Valmet

Advance Process Control – The Technology



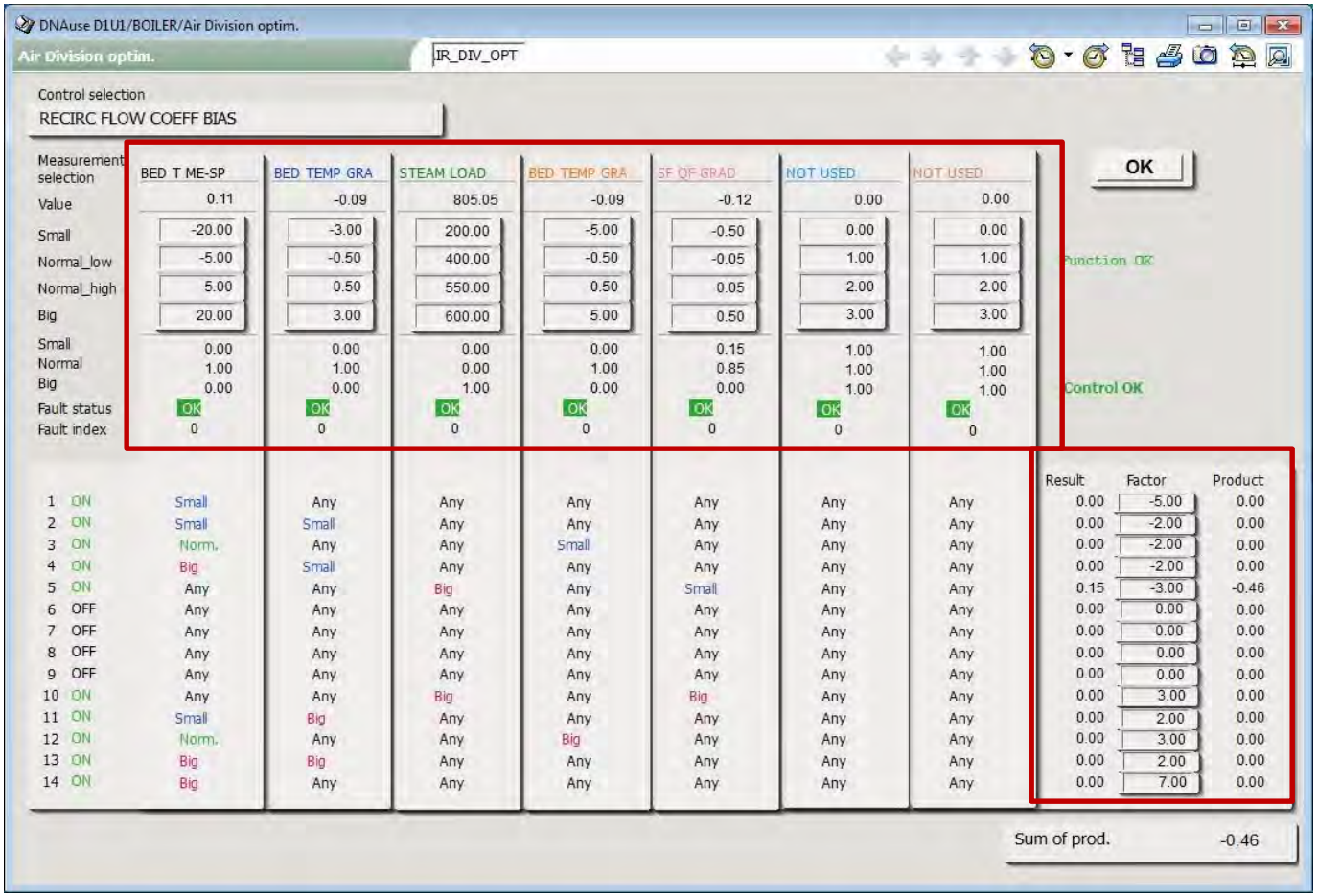
Valmet

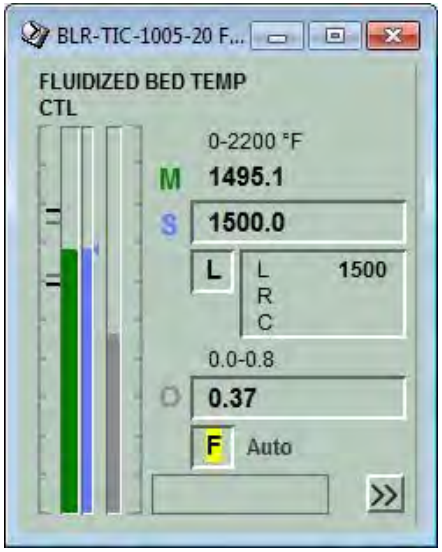
Combustion Manager – APC Structure



Valmet

Multiple Input vs. PID controller





Valmet

Grant Town Power Plant (West Virginia)

Problem: Each quarter I get dinged on operating costs, particularly limestone. Can I reduce limestone usage while still meeting my emissions requirements?

Valmet

Facility facts

- Facility commissioned in 1992
- Boiler rated at 552 million Btu/hr
- Steam capacity 400,000 pounds per hour (Burns GOB fuel)
- Main steam conditions 955^{0}F and 1370 psig
- Primary air injected above and under the grid. PA ~ 66% of total air
- Secondary air is injected into the dilute phase
- High pressure blowers to fluidize loop seal
- DCS: Foxboro IA series

Valmet

The Goals…

- Optimize combustion
- Reduce limestone consumption
- Maintain emission compliance

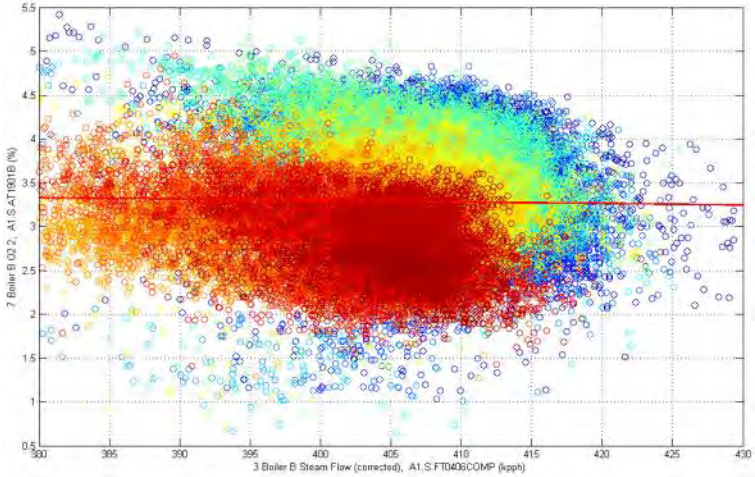
The Work…

- Re-designed the air controls
- Modified fuel controls, bed level, and bed temp controls
- Valmet Advanced Process Controller added to control air distribution, fuel distribution, O_2 optimization and bed temperature optimization
- Valmet advanced BTU compensator to compensate for fuel quality fluctuations

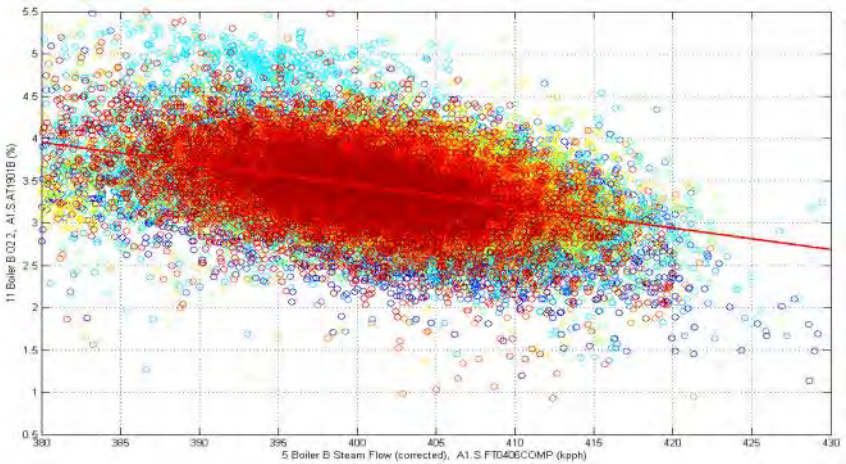
Valmet

Results: O2 vs. Steam Flow

2009



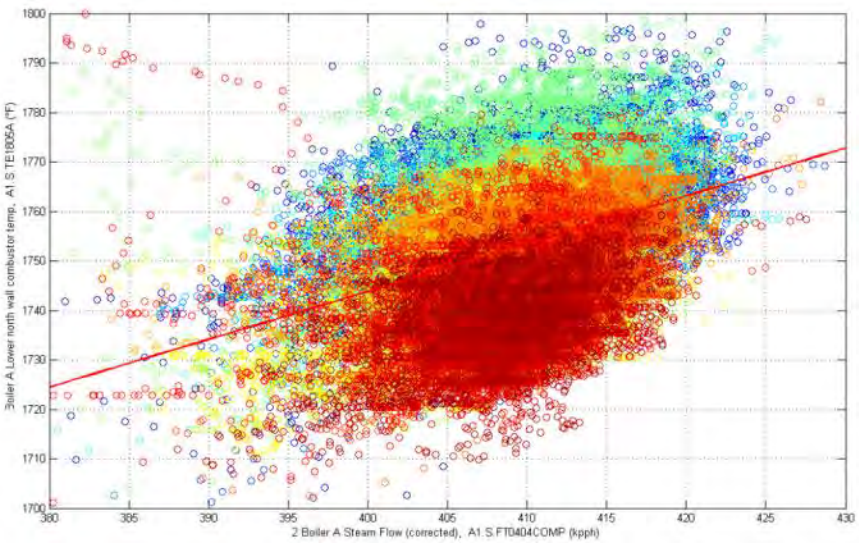
2011



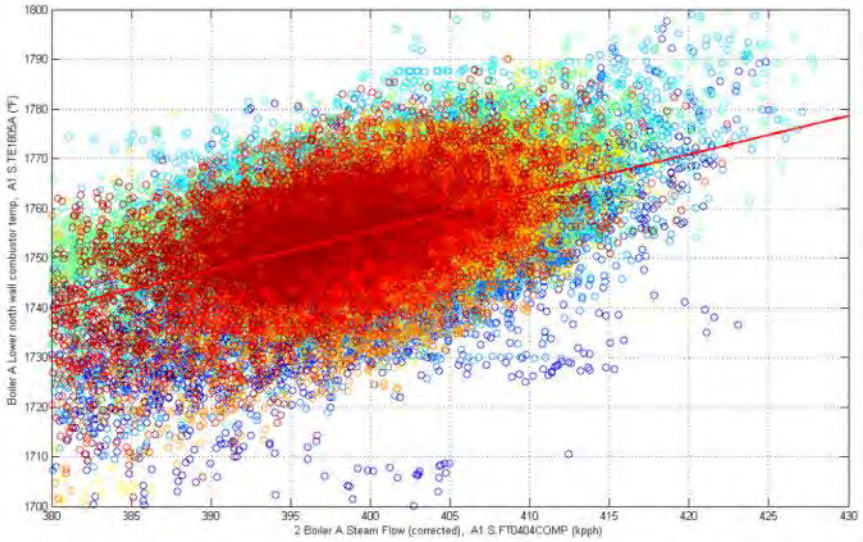
Valmet

Results: Bed Temp Vs. Steam Flow

2009



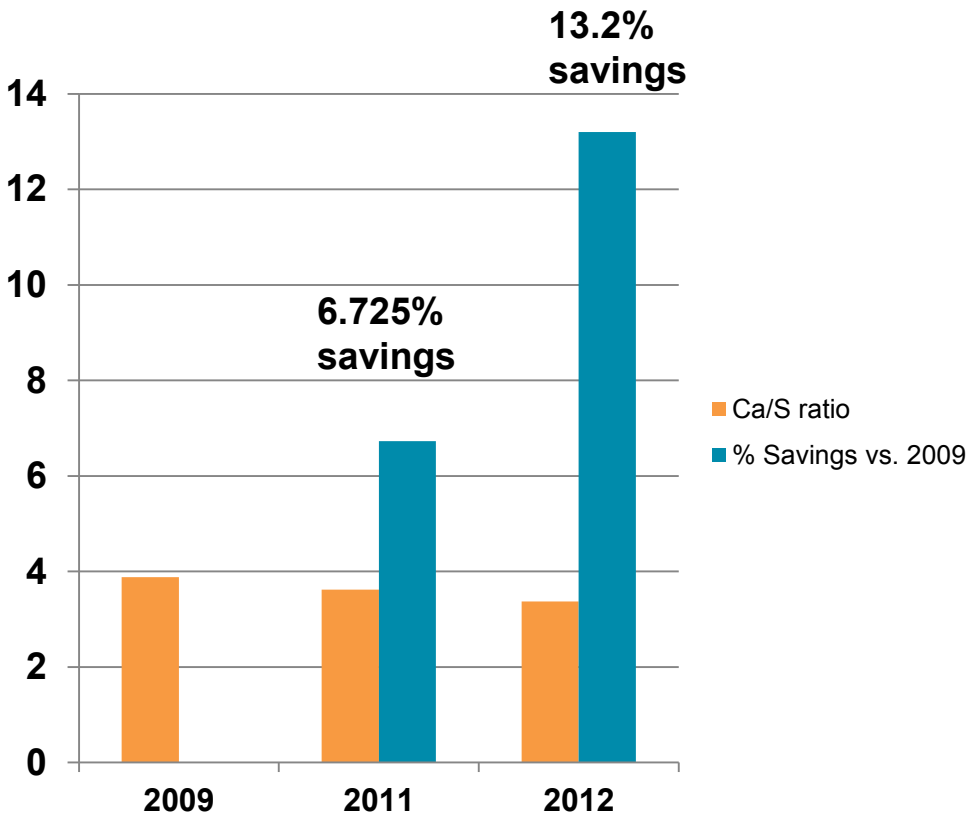
2011



Valmet

Sustainable results

- Operator acceptance excellent
- System in automatic greater than 90% of the time
- Operational uniformity across shifts

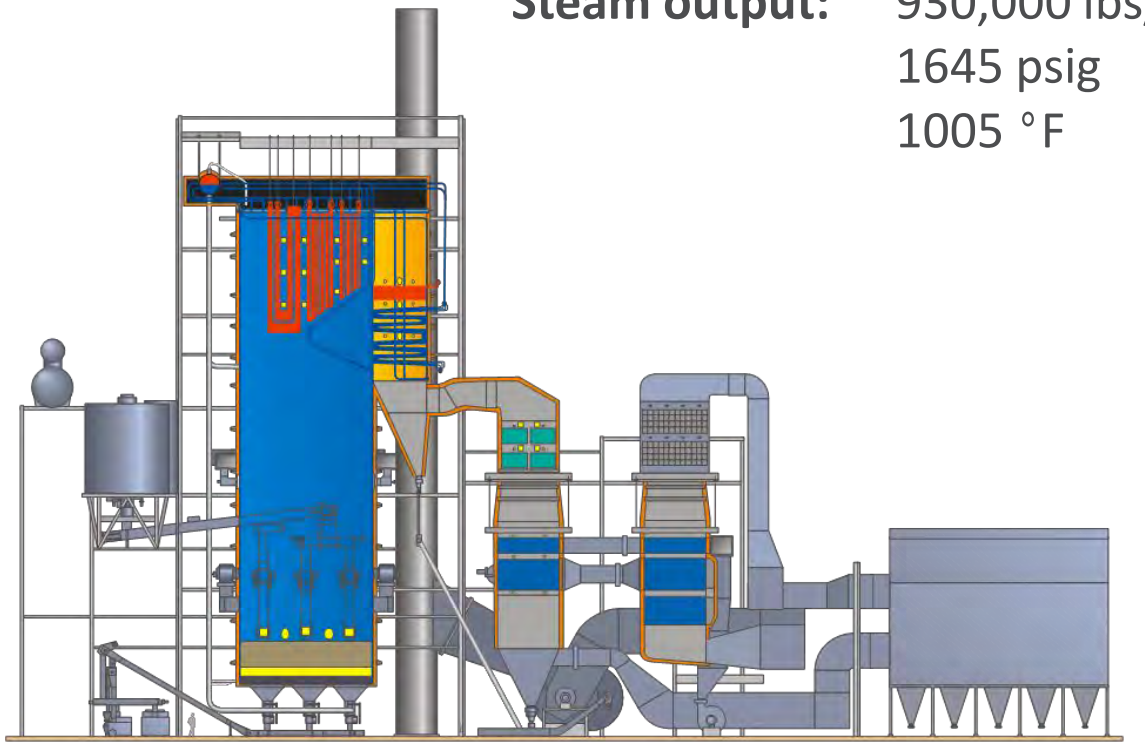


Valmet

Gainesville
Renewable Energy Center

Valmet HYBEX boiler
Bubbling Fluidized Bed (BFB) technology

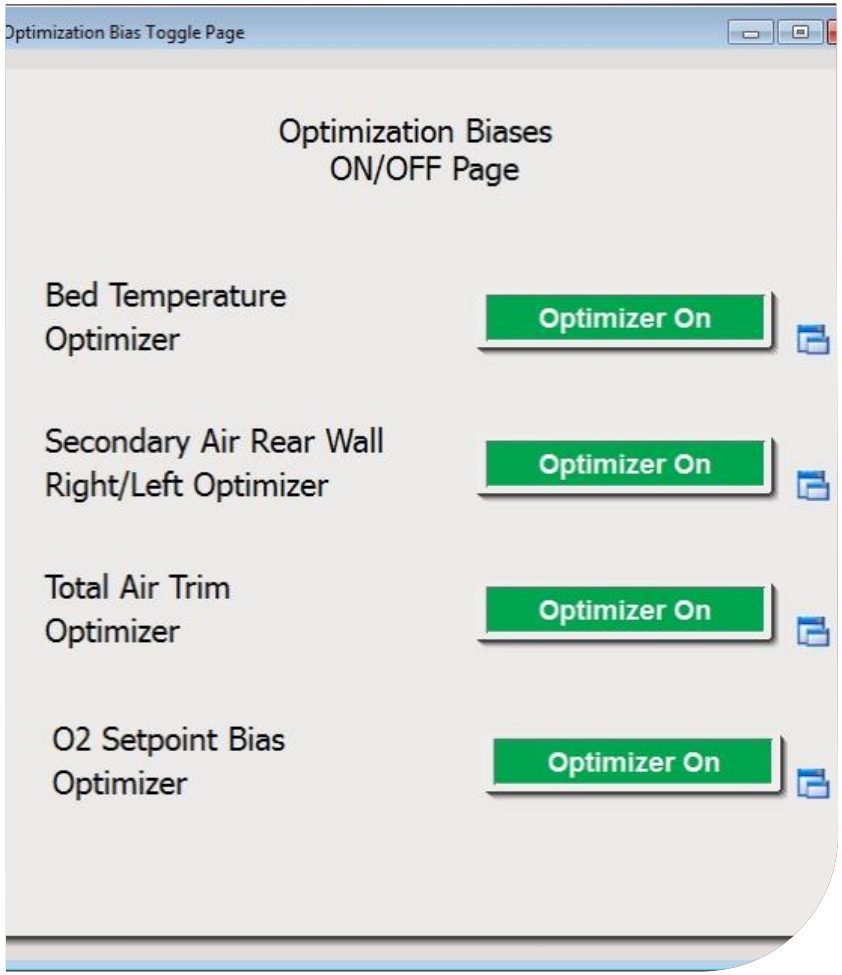
Steam output: 930,000 lbs/hr (100 MWe)
1645 psig
1005 °F



Valmet

APC structure at GREC

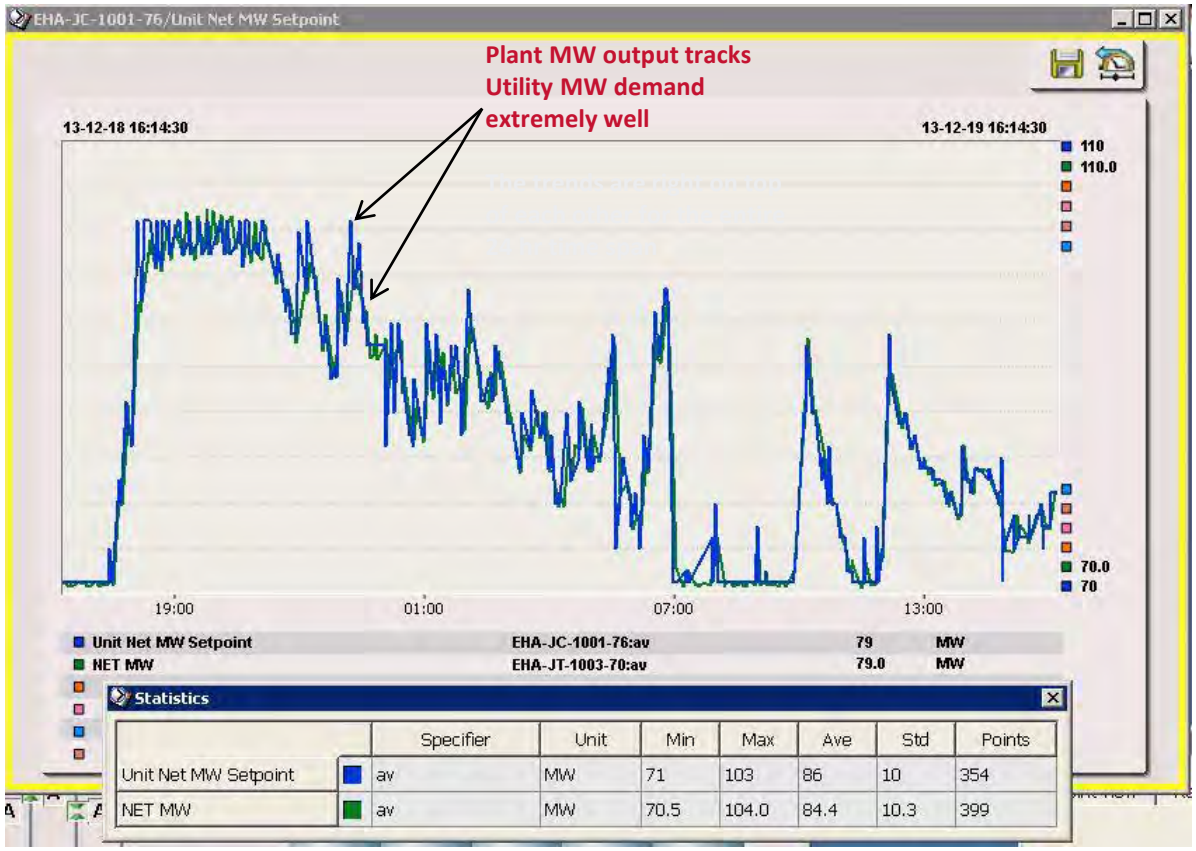
- The system includes 4 advanced process controllers
- Bed temp APC minimizes bed temp & NO_x excursions especially during fast load changes
- Rear wall air distribution APC improves furnace symmetry
- Total air trim APC modifies total air demand based on fuel quality
- O2 trim APC optimizes between CO, NO_x and efficiency targets



Valmet

Unit load profile

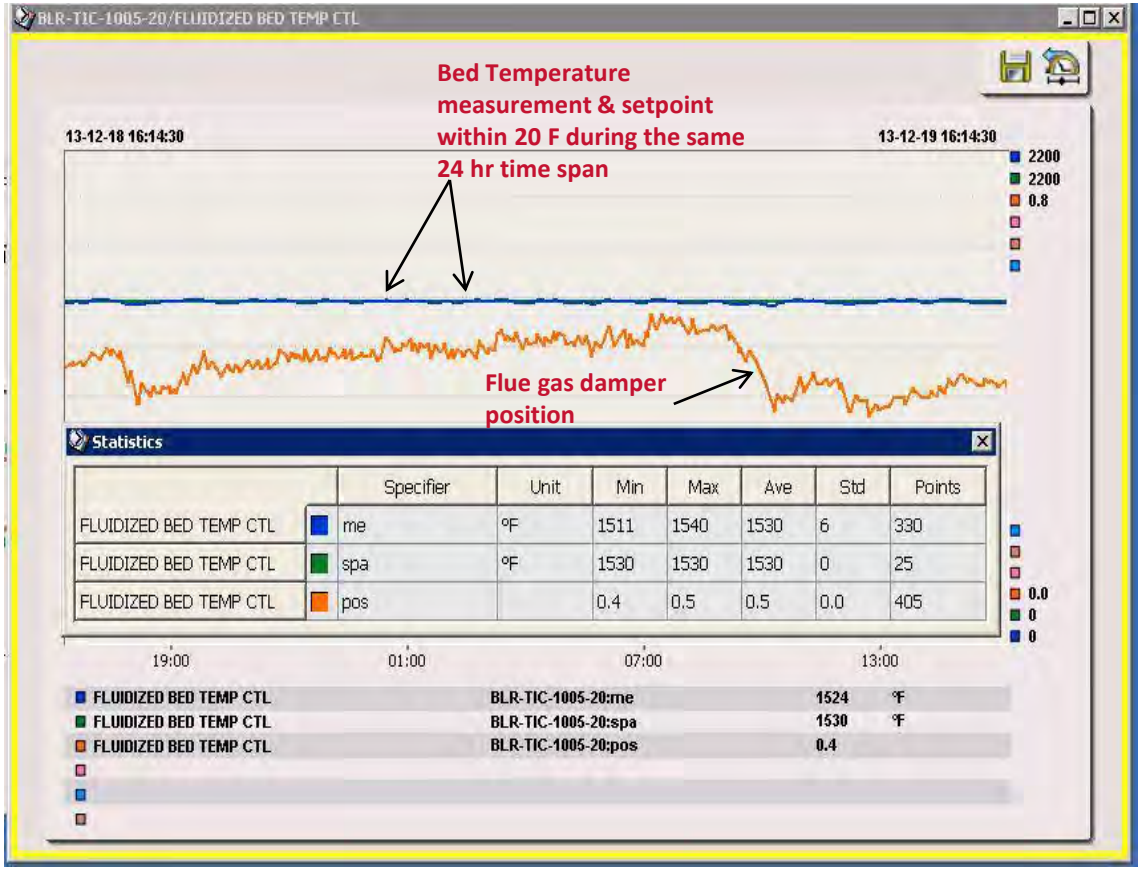
- Unit load is dispatched at 3%/min
- Time span is 24 hrs
- Combustion controls run in automatic
- Metso's optimization controls have no trouble keeping up with load demand



		Specifier	Unit	Min	Max	Ave	Std	Points
Unit Net MW Setpoint		av	MW	71	103	86	10	354
NET MW		av	MW	70.5	104.0	84.4	10.3	399

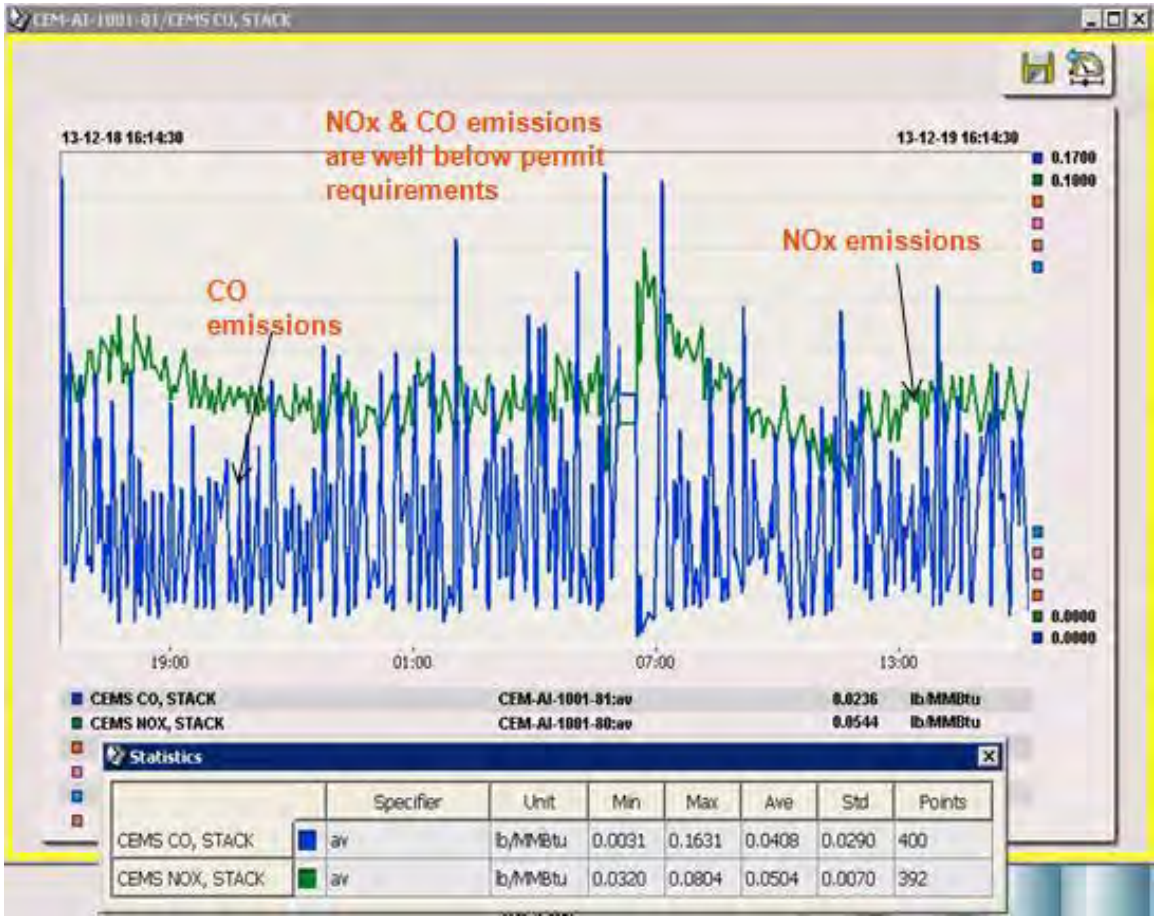
Bed temperature trend

- The bed temperature is very stable
  - Operator setpoint = 1530 F
  - Maximum measured value = 1540 F
  - Minimum measured value = 1511 F
- Standard deviation of 6 degrees F



CO & NO_x emissions

- The CO & NOx emissions were below the permit requirements
- CO permit = 0.08 lbs/MMBTU
- Measured CO 24hr average = 0.0408 lbs/MMBTU
- NO_x permit = 0.07 lbs/MMBTU
- Measured NO_x 24hr average = 0.0504 lbs/MMBTU
- Measured average backpass O_2=2.3 %. The design setpoint of 2.8%
- Translates to a ~ 0.3% improvement in boiler efficiency



Valmet

The take home message

- Process control with APC packages are going to be the new norm
- MPC & Fuzzy based controller technology are well established
- Projects typically pay for itself in less than a year but…
- Do your homework!
- No one size fits all solution
- And finally, optimization is a continuous process

Valmet


Valmet
FORWARD