Instrumentation, Controls & Electrical

SIEMENS

Guaranteed reductions in NOx emissions and fuel consumption for Drax`s 660MW biomass boilers

Clean Coal Technologies 2017

Cagliari 09th of May 2017

Dietrich-Georg Ellersiek Siemens AG PS CD DI OPT

© Siemens AG 2015. All rights reserved.

SPPA-P3000 combustion optimizer reduces emission values and improves plant efficiency

SIEMENS

Runback Plus
Life Time Plus

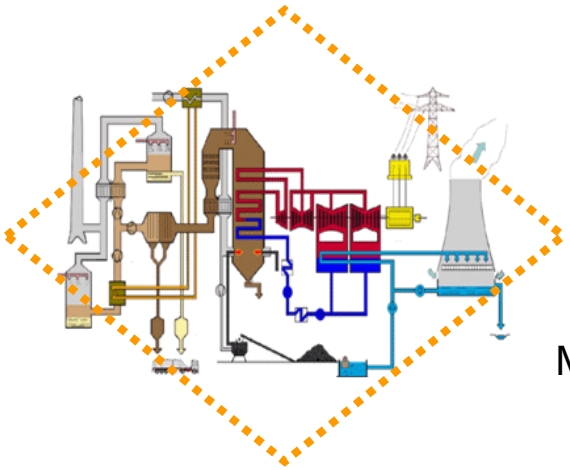
High availability

- Laser Based Combustion Optimization
- Hybrid-Combustion Optimization

Low Loss Start
Combustion Optimizer
Soot Blower Optimizer

High efficiency

Temperature Optimizer
Low Throttling
Best Point



Fast Start
Fast Ramp
Frequency Control

High flexibility

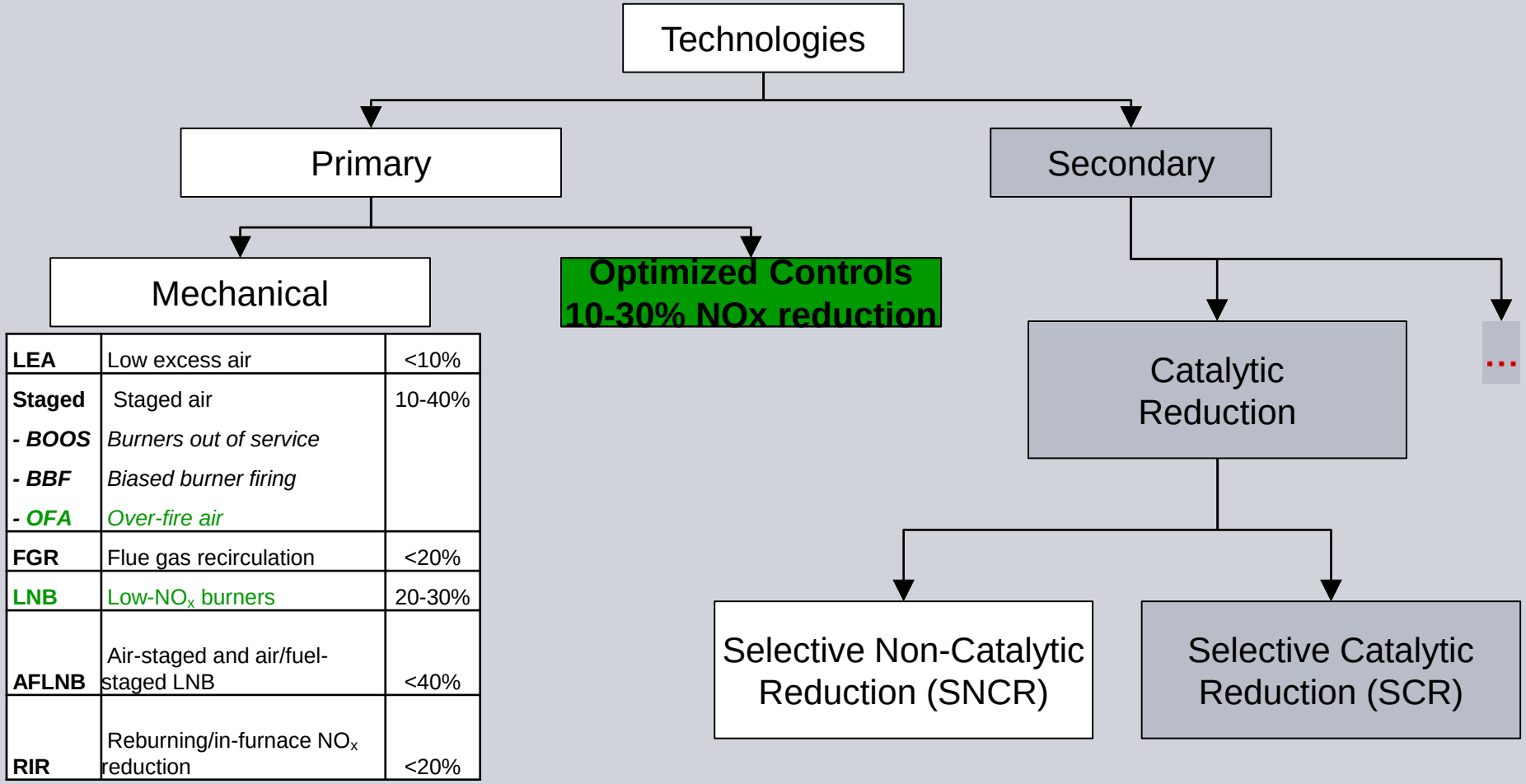
Dispatch Control
Minimum Load Reduction
Maximum Load Plus

Low emissions

NO_x Minimizer
CO_2 Minimizer
LoI Minimizer

Overview of Primary NO_x Reduction Measures - Technologies to reduce NO_x

SIEMENS



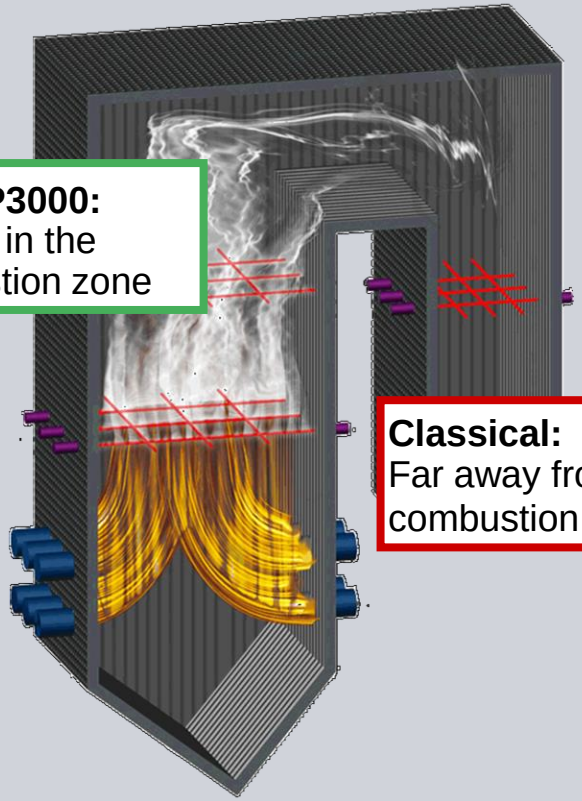
LEA	Low excess air	<10%
Staged ***- BOOS*** ***- BBF*** ***- OFA***	Staged air *Burners out of service* *Biased burner firing* *Over-fire air*	10-40%
FGR	Flue gas recirculation	<20%
LNB	Low-NO_x burners	20-30%
AFLNB	Air-staged and air/fuel-staged LNB	<40%
RIR	Reburning/in-furnace NO_x reduction	<20%

© Siemens AG 2015. All rights reserved.

Unique direct measurement and optimization inside combustion zone

SIEMENS

Measurement positions



SPPA-P3000:
Directly in the combustion zone

Classical:
Far away from the combustion zone

homogenous combustion
→ **increased efficiency**
→ **reduced emissions**

Measurement, Calculation, Optimization

Laser based Measurement of Temperature- and Concentrations- (H_2O, O_2, CO, ...) values directly in the combustion zone

Calculation and evaluation of temperature- and concentration distribution through Computer-Aided Tomography (CAT)

Optimization through hybrid combustion control, using classical model based control structures and adaptive neural network

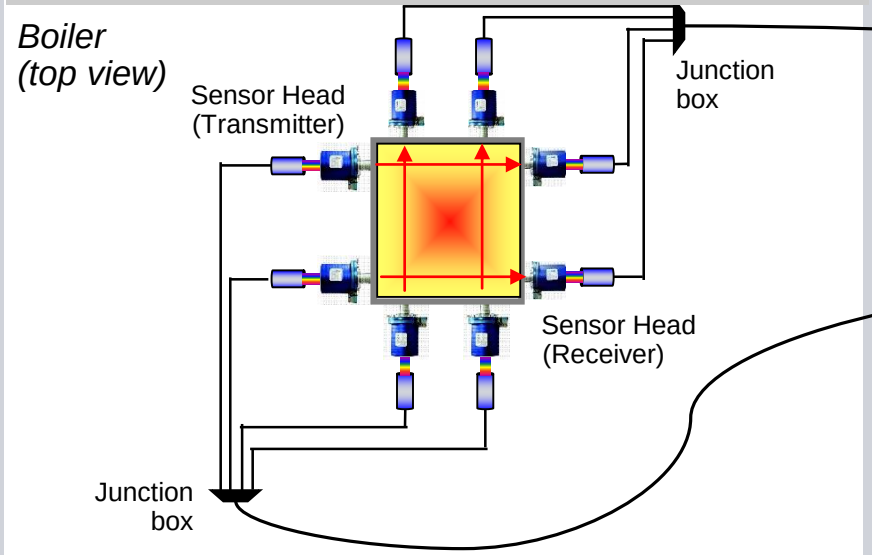
Temperature distribution in the combustion zone

© Siemens AG 2015. All rights reserved.

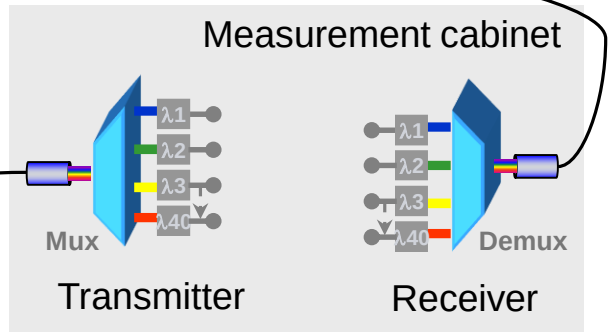
Approved Technology...
designed for the harsh boiler environment

SIEMENS

Boiler



Electronic equipment room



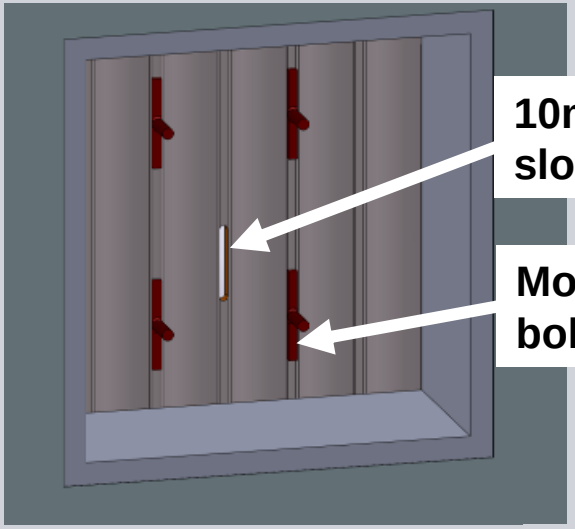
- No sensitive electronics near the boiler
- **Automatic cleaning (rodders + air)**
- **Online alignment (SensAlign™)**
- Long service life time 100,000 h (use of standard telecommunication components)
- Standard system with 15 paths
- Modular variation of paths

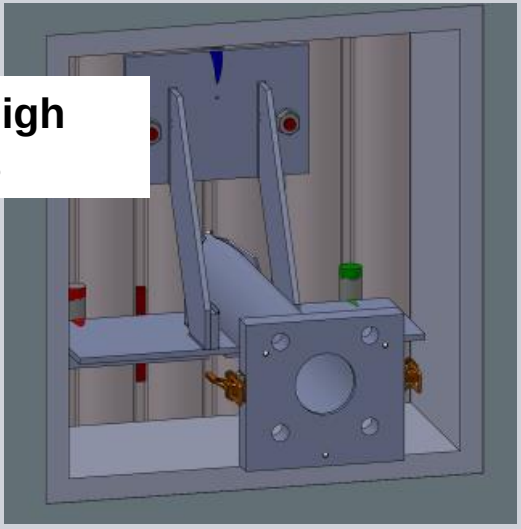
- Central installation of sensitive components,
  e.g. in electronic equipment room
- Measurements currently possible:
  - **Temperature, O_2, CO, H_2O**
  - Further development potential

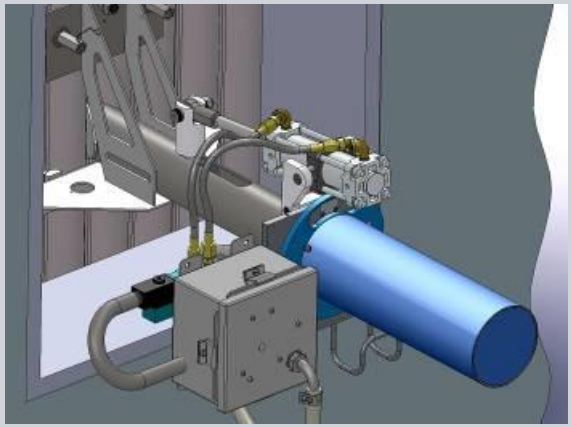
© Siemens AG 2015. All rights reserved.

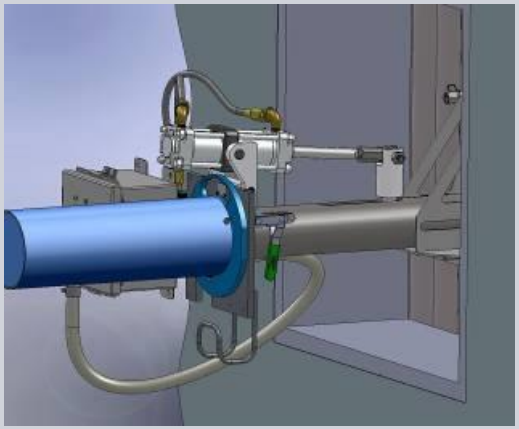
Minimum effort required for installation of measuring equipment

SIEMENS





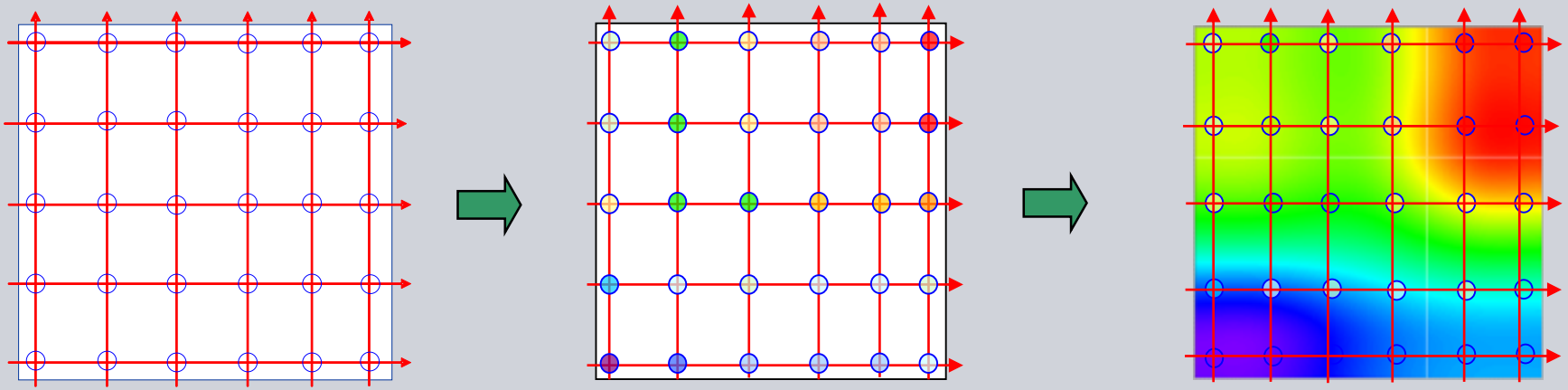




© Siemens AG 2015. All rights reserved.

Measurement, Reconstruction und Interpolation (CAT)

Path-average values → **Values of intersection points** → **Temperature-, Distribution of Concentration**



→ **CAT Software (Medicine technique)**

Computer Aided Tomography

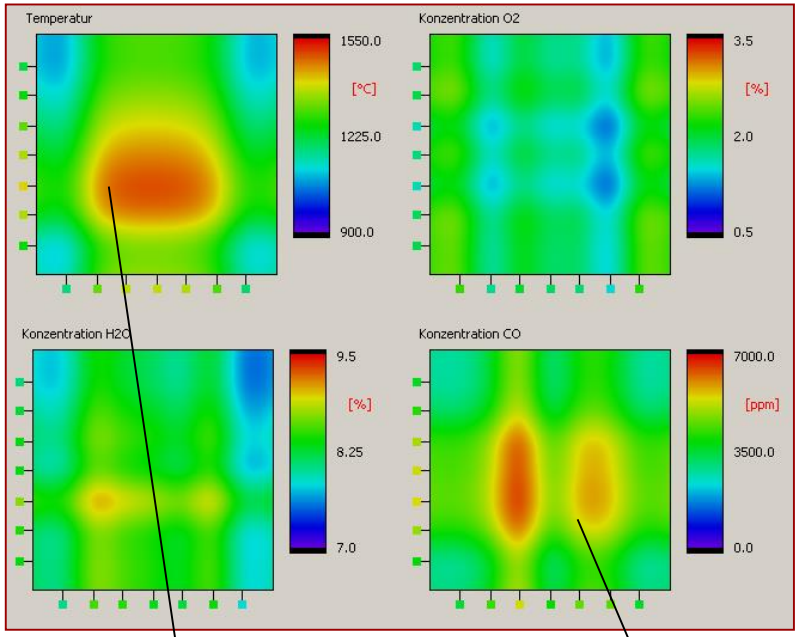
© Siemens AG 2015. All rights reserved.

Elimination of high CO values; Displacement of temperature center; Spreading temperature center

Unit load: 330 MW, Operation with combustion of animal meal of 2x3 t/h

Total combustion air flow is constant

Secondary air flow for all burners equal (auto)

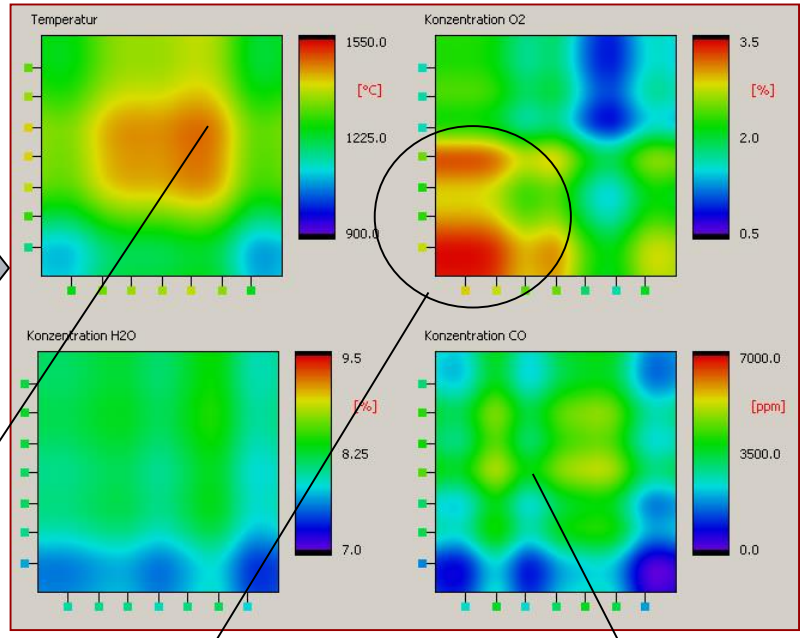


Br.64/74

more CO

Displacement of temperature center

Increasing of secondary air flow for burner 64 & 74: +20%



Local more O2

less CO

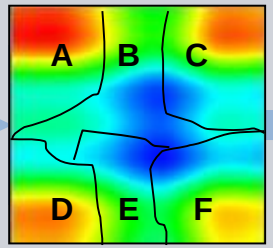
© Siemens AG 2015. All rights reserved.

Hybrid combustion optimization and – controlling: Model based controller

SIEMENS

Boiler

Measurements, e.g. from Laser



N x
Control variables,
e.g. O_2, CO in area A

N x
Setpoints

Measurements, e.g. Load

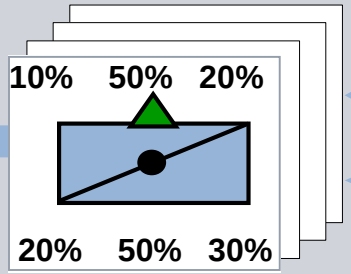
Feedforward & Adaption

PI

Model-based controller

N x

K x
Actuating variables

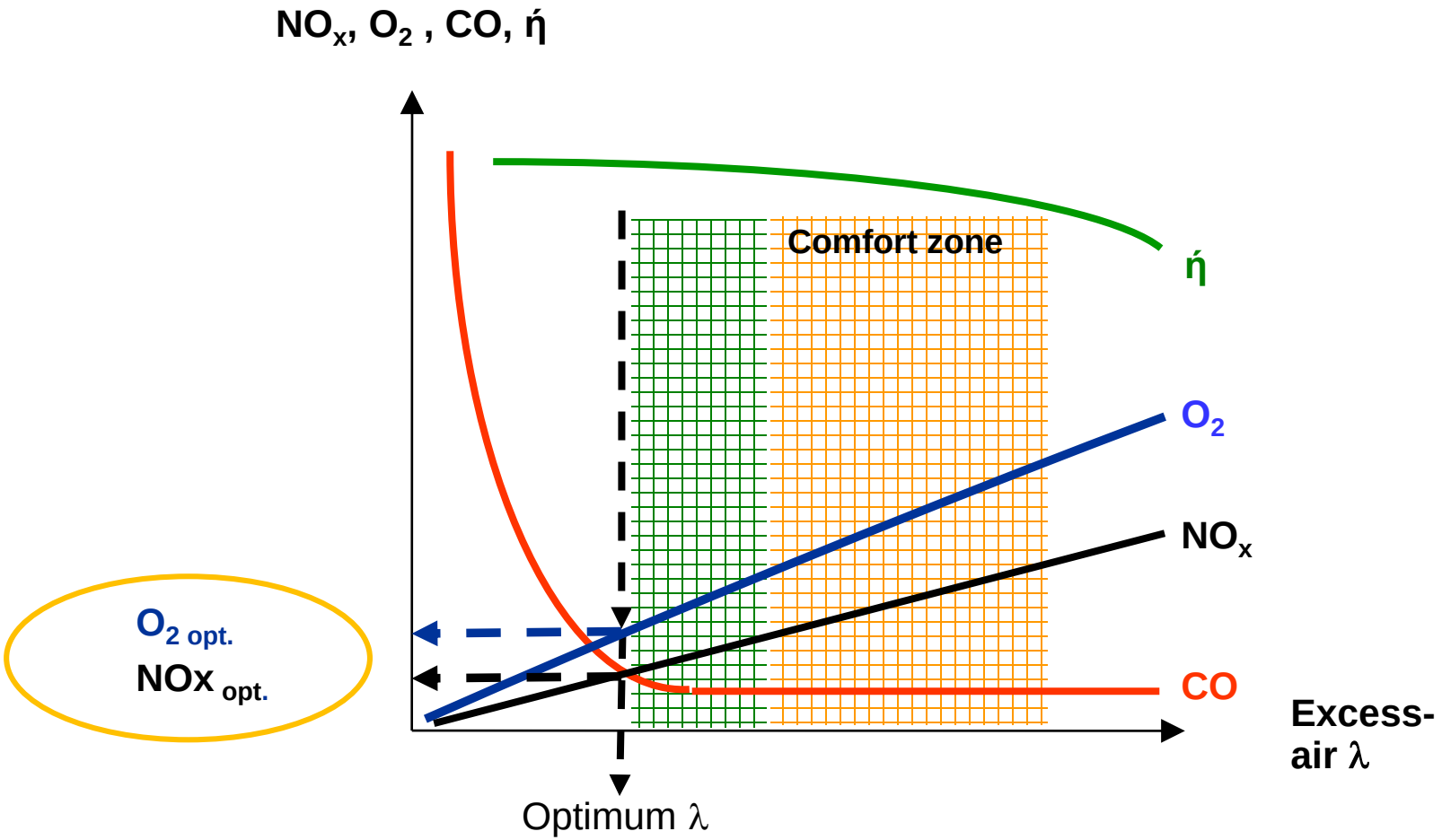


N x K
Constant
Loading factors

N x
Controller-output

© Siemens AG 2015. All rights reserved.

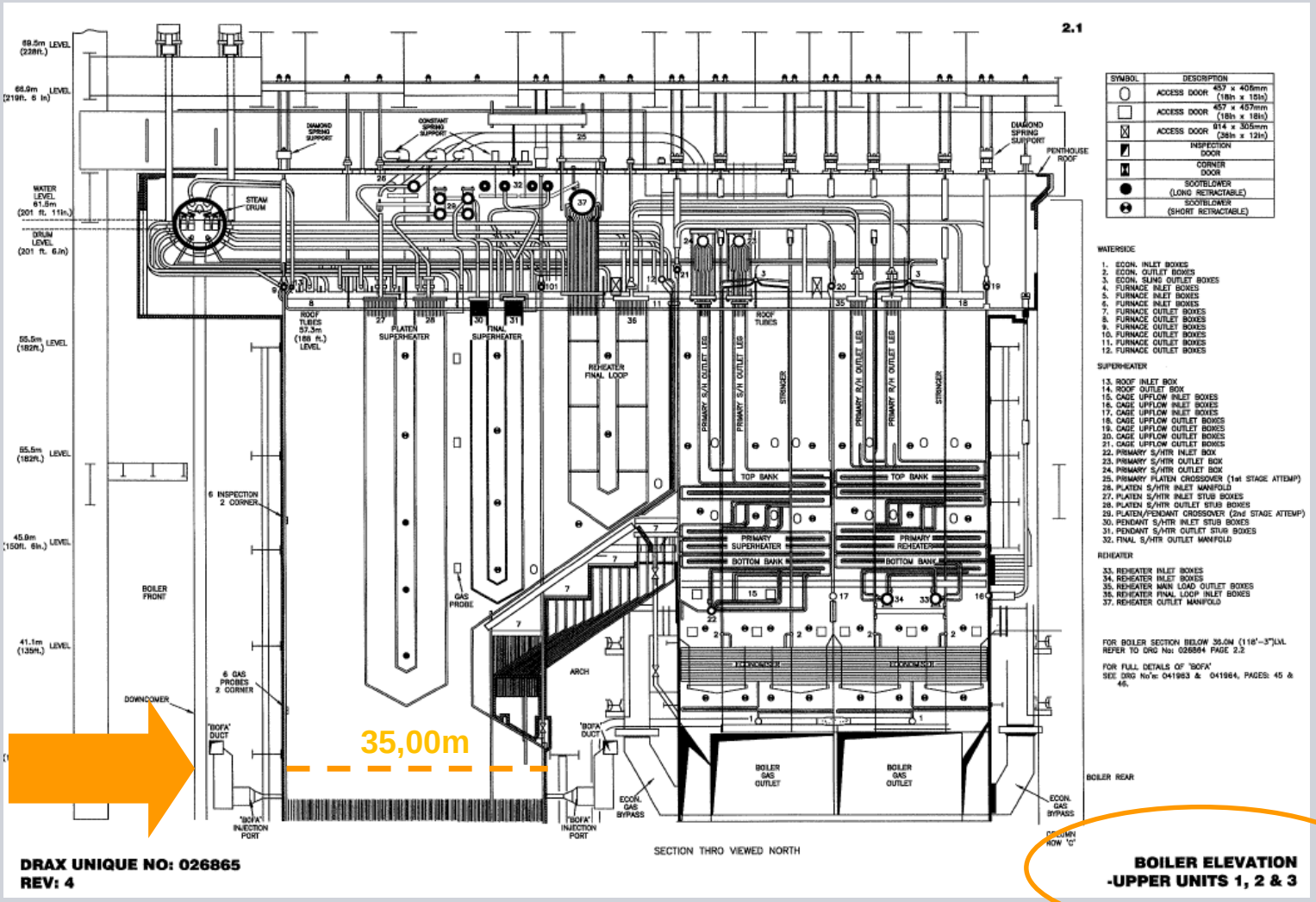
Primary NOx reduction:
Minimizing excess air and simultaniosly keeping CO values in range



© Siemens AG 2015. All rights reserved.

Drax biomass application - Laser Measurement Level

SIEMENS



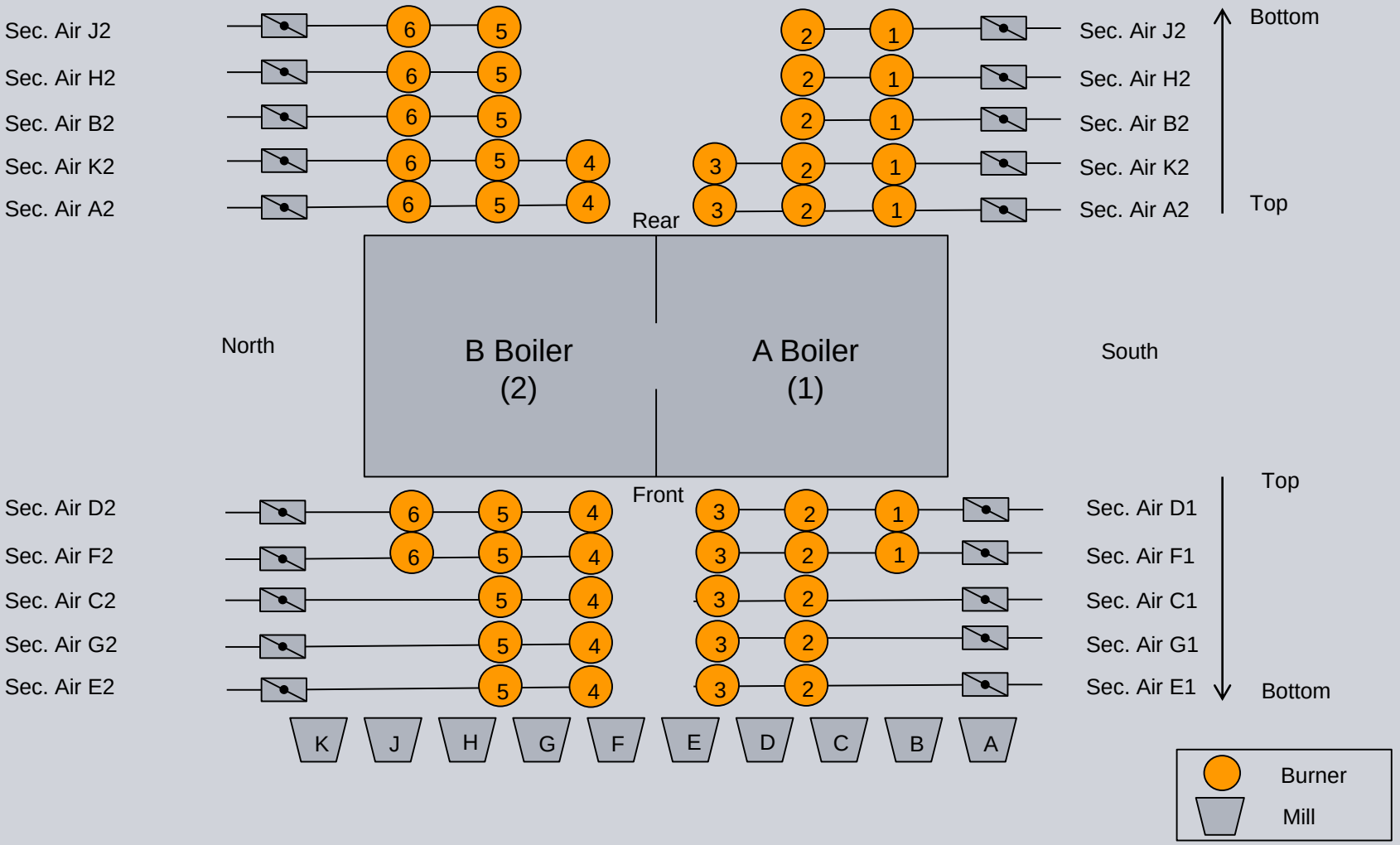
© Siemens AG 2015. All rights reserved.

SIEMENS

Drax biomass application - Laser Head Assembly

s reserved.

Designation boiler, burners and dampers

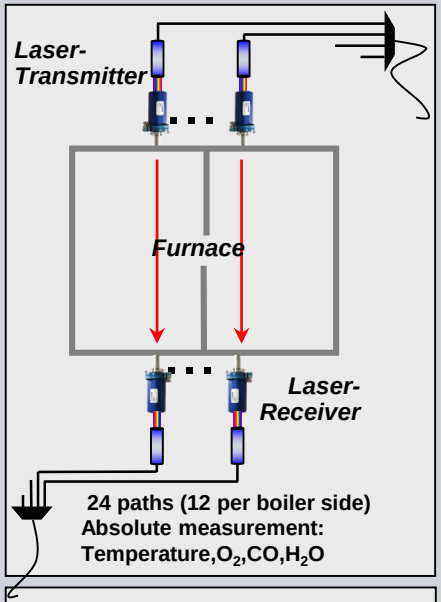


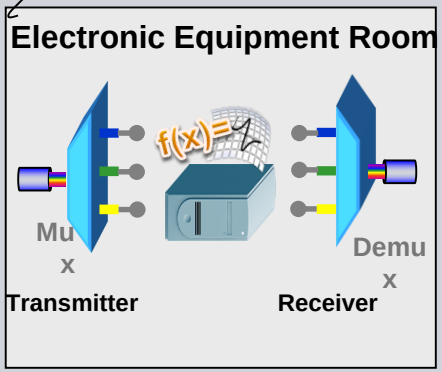
© Siemens AG 2013. All rights reserved

Drax biomass application
Measurement and closed-loop optimization

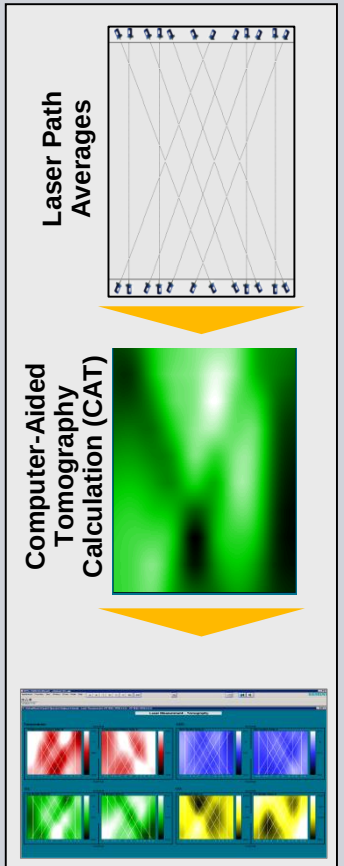
SIEMENS

Laser-Measurement

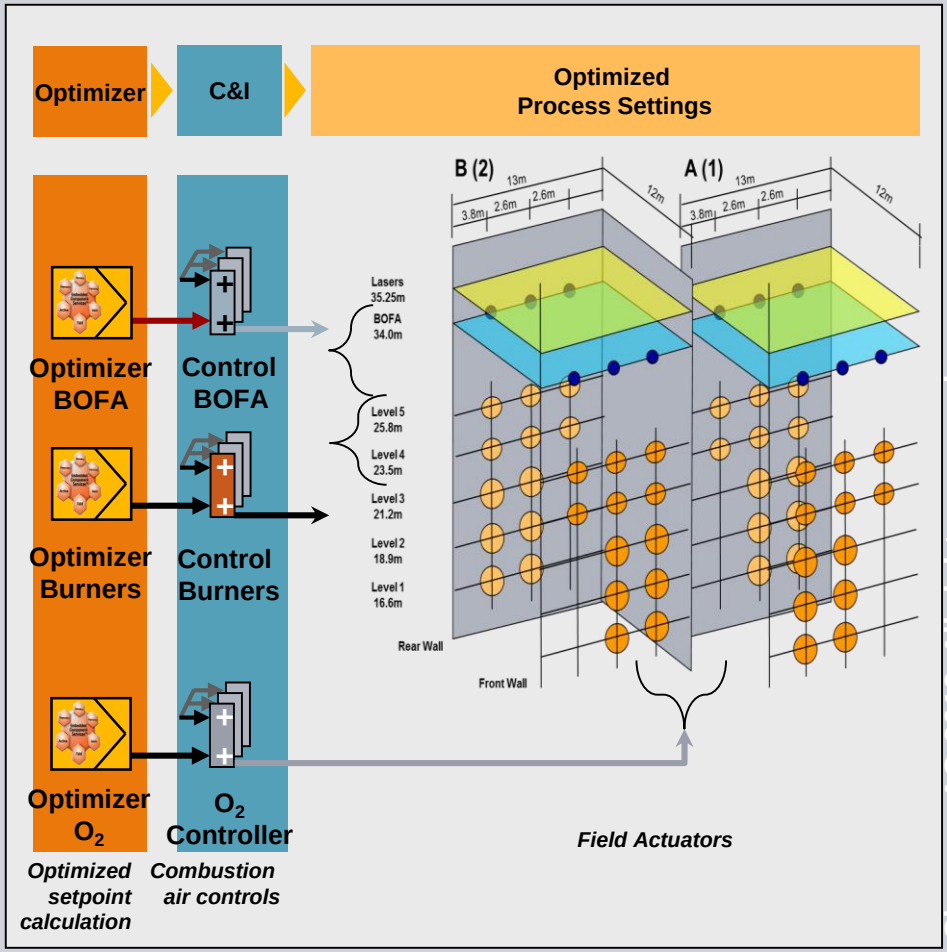




CAT Calculation

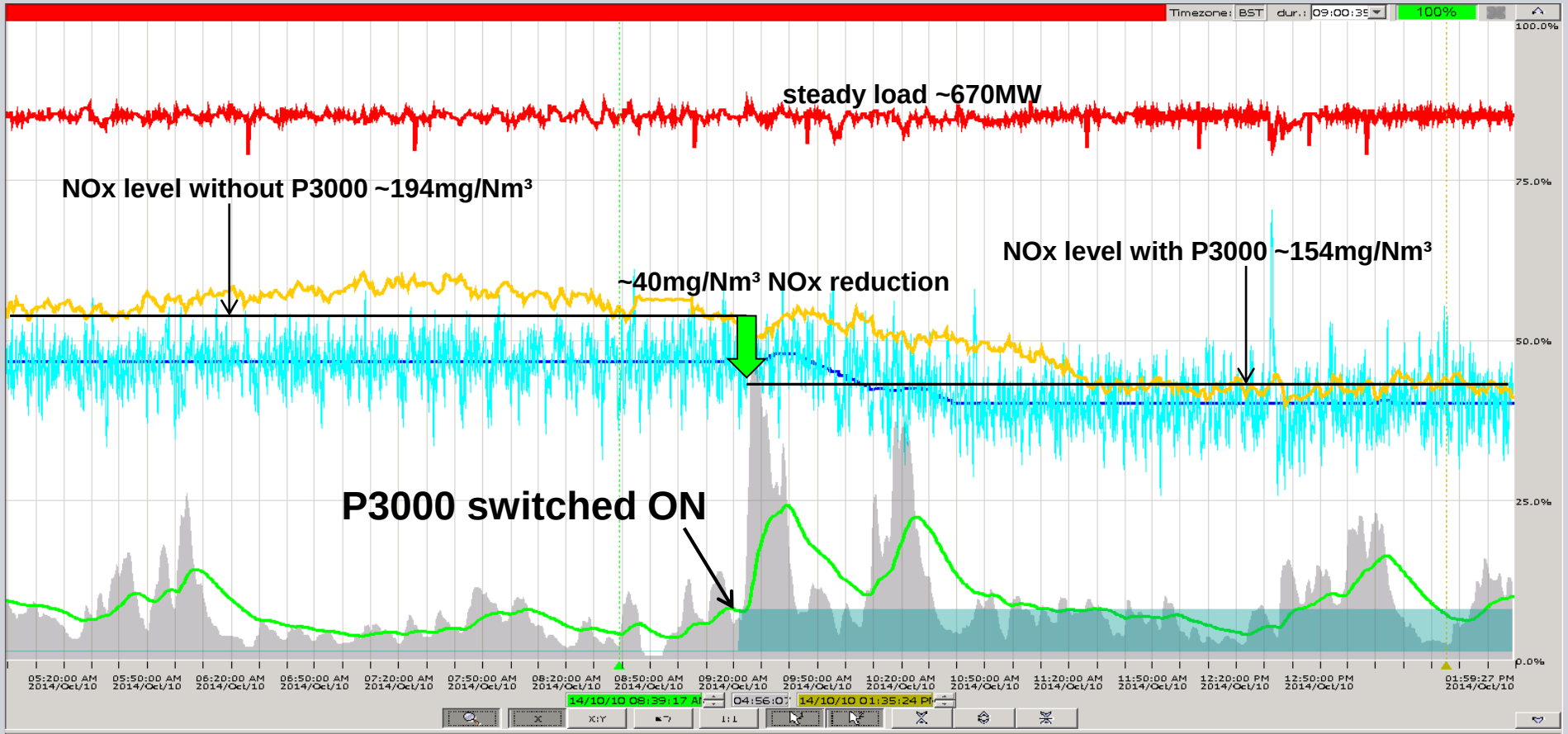


Combustion Optimization



© Siemens AG 2013. All rights reserved

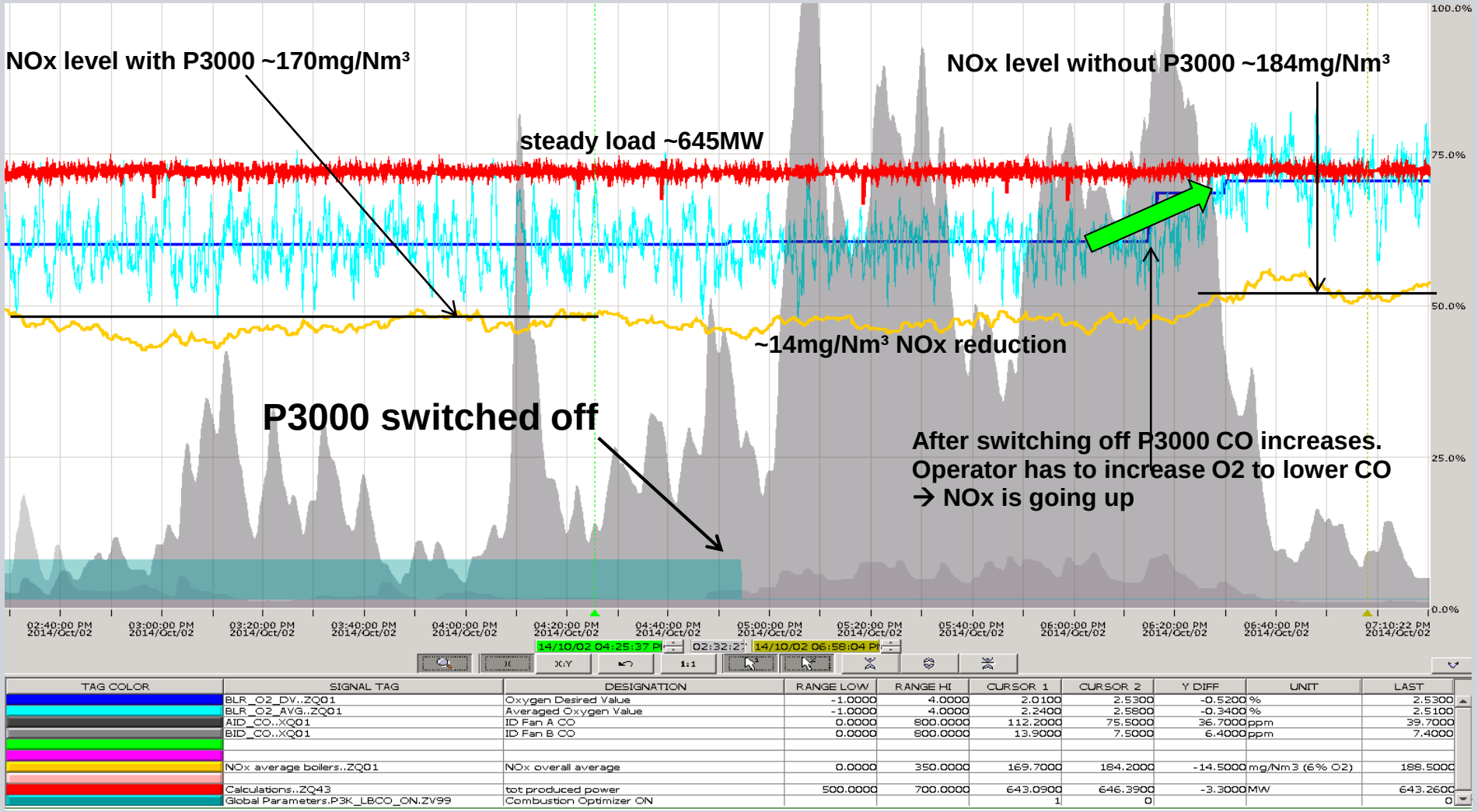
Drax biomass application –
NOx reduction with SPPA-P3000 Combustion Optimizer



TAG COLOR	SIGNAL TAG	DESIGNATION	RANGE LOW	RANGE HI	CURSOR 1	CURSOR 2	Y DIFF	UNIT	LAST
	BLR_O2_DV..ZQ01	Oxygen Desired Value	0.0000	5.0000	2.3400	2.0100	0.3300	%	2.0100
	BLR_O2_AVG..ZQ01	Averaged Oxygen Value	0.0000	5.0000	2.1100	1.8500	0.2600	%	2.0800
	CO average boilers..ZQ01	CO overall average, 6% O2 corr.	0.0000	1000	22.4405	25.9935	-3.5531	mg/Nm3	115.1346
	CO average boilers..ZQ02	CO overall average 15 min, 6% O2 corr	0.0000	1000	41.0052	71.0390	-30.0338	mg/Nm3	100.1078
	NOx average boilers..ZQ01	NOx overall average	0.0000	350.0000	193.8500	154.0500	39.8000	mg/Nm3 (6% O2)	144.1000
	Calculations..ZQ43	tot produced power	500.0000	700.0000	670.7200	669.3400	1.3799	MW	670.7000
	Global Parameters.P3K_LBCO_ON.ZV99	Combustion Optimizer ON			0	1			1

© Siemens AG 2015. All rights reserved.

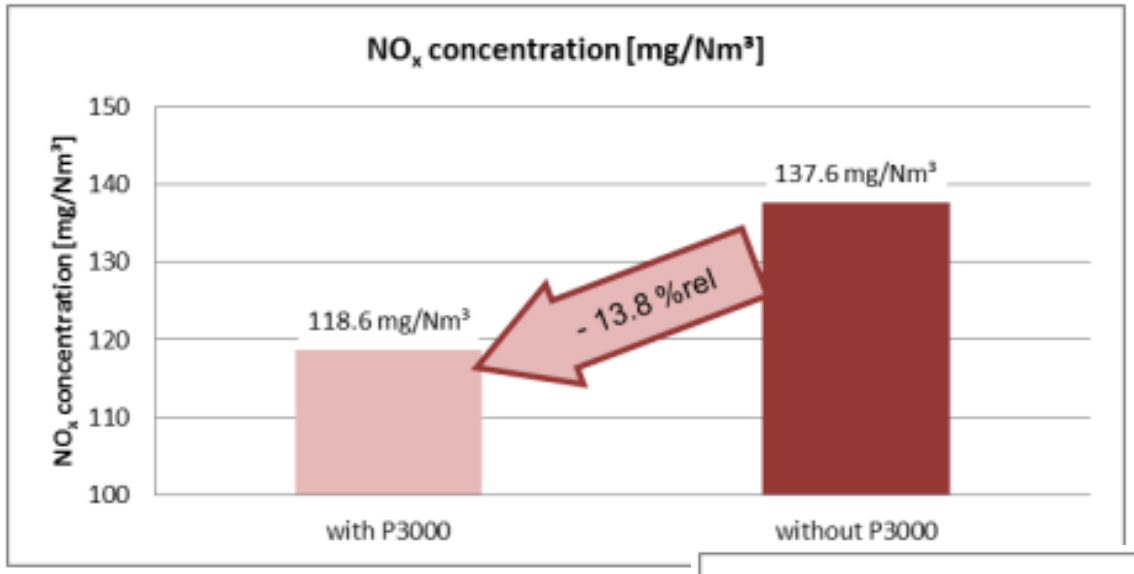
Drax biomass application-
Nox reduction with SPPA-P3000 Combustion Optimizer

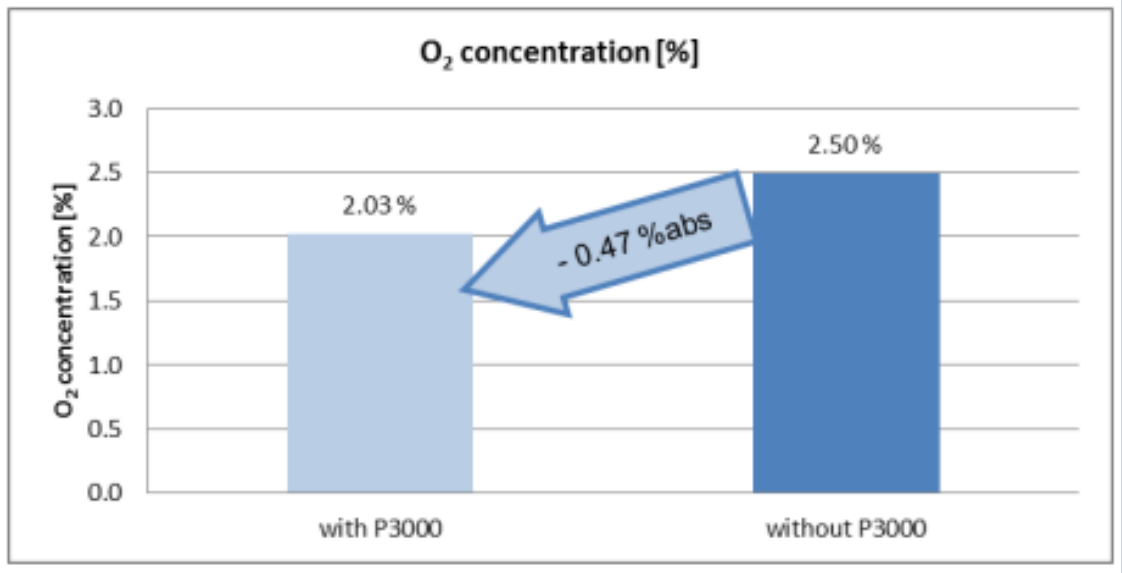


TAG COLOR	SIGNAL TAG	DESIGNATION	RANGE LOW	RANGE HI	CURSOR 1	CURSOR 2	Y DIFF	UNIT	LAST
	BLR_O2_DV..ZQ01	Oxygen Desired Value	-1.0000	4.0000	2.0100	2.5300	-0.5200	%	2.5300
	BLR_O2_AVG..ZQ01	Averaged Oxygen Value	-1.0000	4.0000	2.2400	2.5800	-0.3400	%	2.5100
	AID_CO..XQ01	ID Fan A CO	0.0000	800.0000	112.2000	75.5000	36.7000	ppm	39.7000
	BID_CO..XQ01	ID Fan B CO	0.0000	800.0000	13.9000	7.5000	6.4000	ppm	7.4000
	NOx average boilers..ZQ01	NOx overall average	0.0000	350.0000	169.7000	184.2000	-14.5000	mg/Nm3 (6% O2)	188.5000
	Calculations..ZQ43	tot produced power	500.0000	700.0000	643.0900	646.3900	-3.3000	MW	643.2600
	Global Parameters.P3K_LBCO_ON.ZV99	Combustion Optimizer ON			1	0			0

© Siemens AG 2015. All rights reserved.

Drax biomass application –
13,8% NOx reduction 0,47% O_2 reduction ⇨ 0,24% η





Drax biomass application – Comment from customer

SIEMENS

“Only if you fully understand the biomass combustion process have you got the chance to optimise it,” says Drax engineering manager Les Lemmon. He explains how a combustion optimisation system from Siemens is giving his team greater visibility of what’s happening in their boilers than ever before.

“What we’re doing is pretty unique. The Siemens system is providing information that’s not been seen before”

© Siemens AG 2015. All rights reserved.

SPPA-P3000 Combustion Optimization references
Profitable, reliable and flexible plants - worldwide

SIEMENS

Elverlingsen, Germany
1 x 330 MW, Hard Coal
Melting Chamber Furnace
➔Increase of Biomass Co-Combustion

Neurath D&E, Germany
2 x 630 MW, Lignite
Tangentially Fired
➔Increase of Efficiency
➔Reduction of Slagging
➔Expand Control Range

Niederaußem D, Germany
1 x 300 MW (+2), Lignite
Tangentially Fired
➔Increase of Efficiency
➔Reduction of Slagging
➔Expand Control Range

Niederaußem G, Germany
1 x 630 MW (+1), Lignite
Tangentially Fired
➔Increase of Efficiency
➔Reduction of Slagging
➔Expand Control Range

EDF Cottam 3 & 2, UK
1 x 500 MW, Hard Coal
Front Wall Fired
➔ NO_X-Reduction

EDF West Burton 3 & 1, UK
1 x 500 MW, Hard Coal
Tangentially Fired
➔ NO_X-Reduction

La Cygne 2, USA
1 x 710 MW, Hard Coal
Opposed Fired
➔NO_X-Reduction

Keystone 4, USA
1 x 936 MW, Hard Coal
Opposed Fired
➔Increase of Efficiency

© Siemens AG 2015. All rights reserved.