



3D-Flame Modelling in Power Plant Applications

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Motivation

- Design changes and fuel switching involve several technical risks that impact the safe operation of power plants.
- Unexpected effects like increased water wall wastage due to corrosion, increased slagging and fouling of the heat exchanger surfaces, shifting of the heat release can cause severe operational problems that increase maintenance costs and/or lead to unplanned boiler shutdowns.
- The experience gained with 3D-Combustion Models of RECOM in the past proves that 3D-Flame Modeling can help to identify future operational problems before they become expensive reality.
- Measures to avoid operational problems can be taken already in advance, which leads to significant cost savings.



Customers that benefit from RECOM's combustion models





Coal-Fired Power Station





Combustion Chamber of a 750 MWe Coal-Fired Unit





Jet-Burners and Flames in a Coal-Fired Power Station



Air

Air

Coal

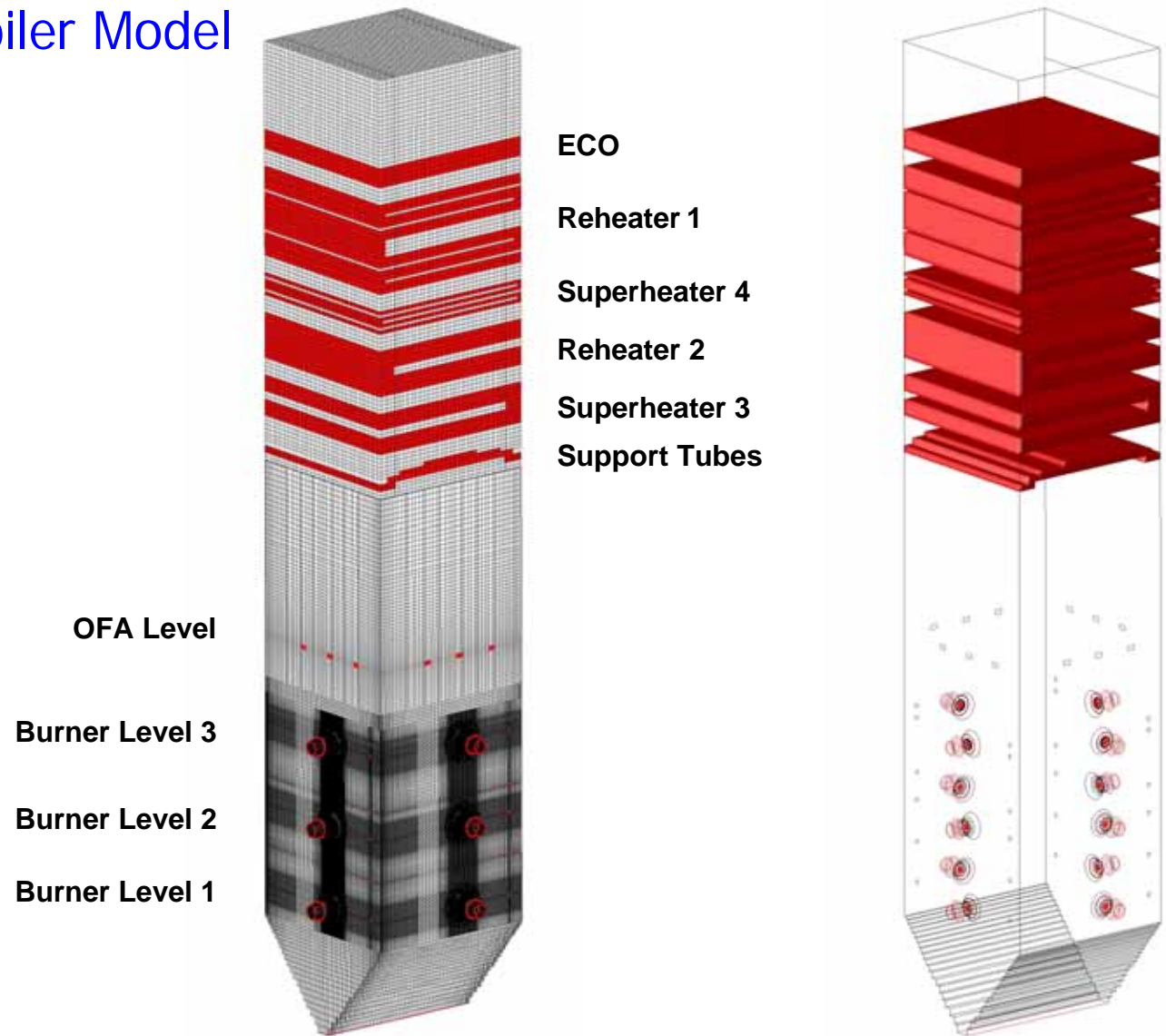
Air

Coal

Air



3D-Boiler Model



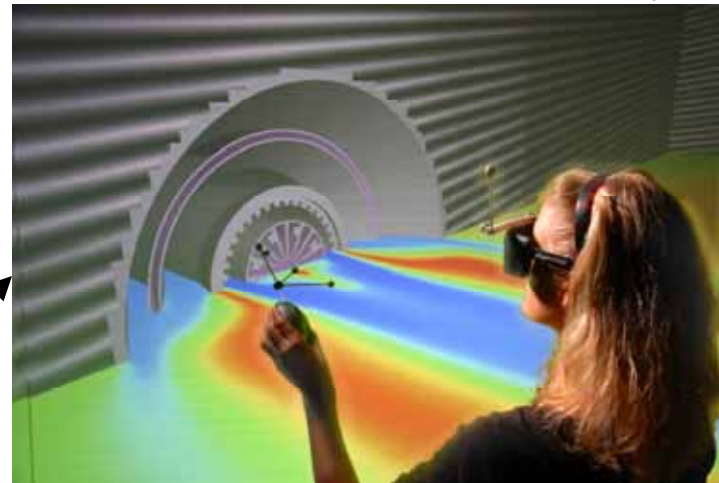


Simulation of the real process in the virtual reality

3D-Boiler Model



Visualisation of computational results in the virtual reality



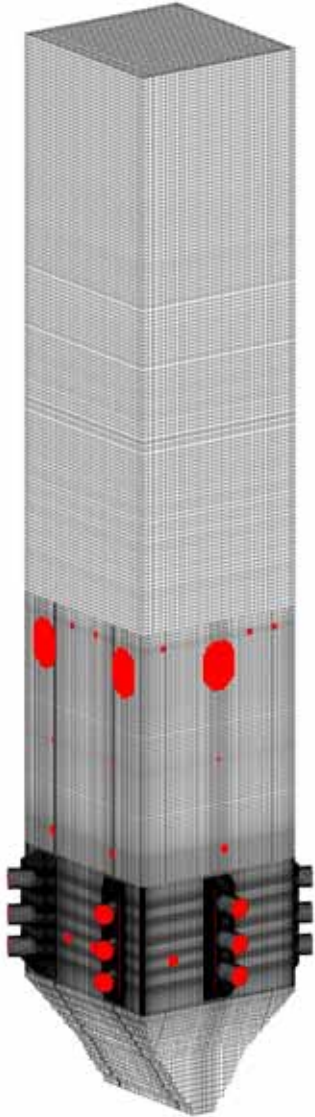
Simulation using Supercomputer
NEC-SX8 at HLRS:



- Improved understanding of the process leads to:
- Reduced Emissions
 - Higher Efficiency
 - Higher Availability of the boiler



Computing times for a boiler model with ca. 9.9 Mio. cells



Parallel Vectorcomputer at HLRS:
NEC-SX8 (8 CPUs = 1 node): 30.0 h



Intel Itanium 2 Montvale Node:
(8 Cores): 189 h (7.9 days)



Important Prerequisites

**Successful application of 3D-combustion modelling
to work on industrial scale problems**

Fast Turnaround:

**Access to high-end
parallel computers**

Details:

**High spatial and
temporal resolution**

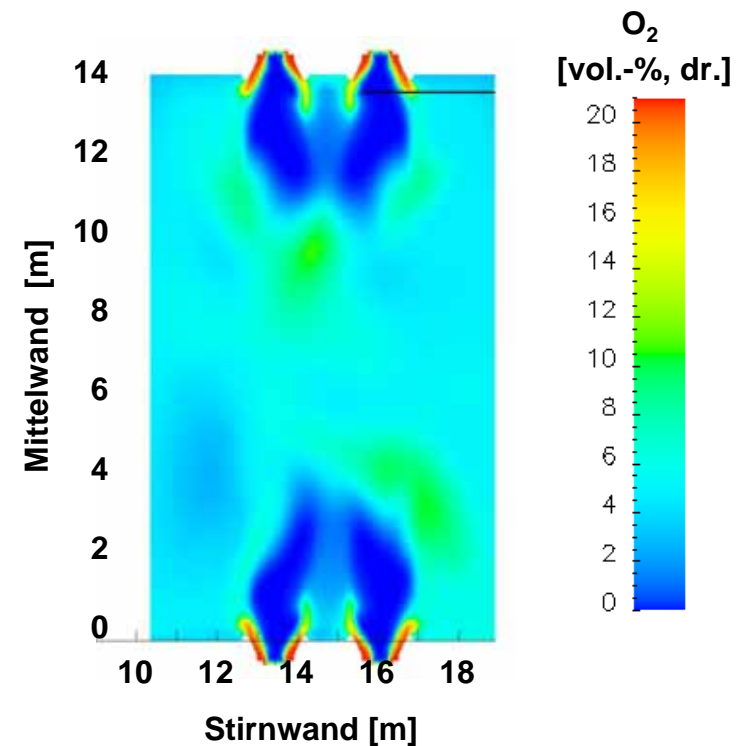
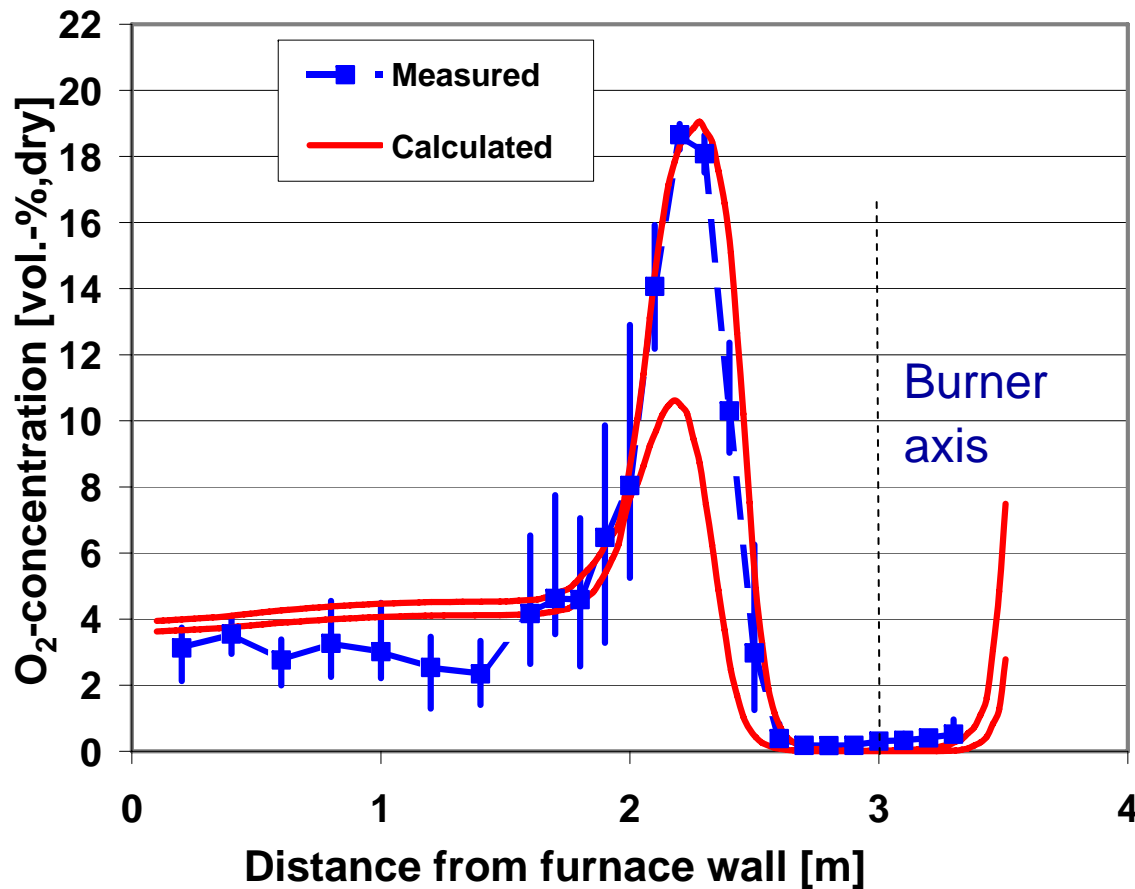
Validation:

**Assessment of the
reliability of the
combustion model**



Example: Reliable O₂-Predictions in front of the burner

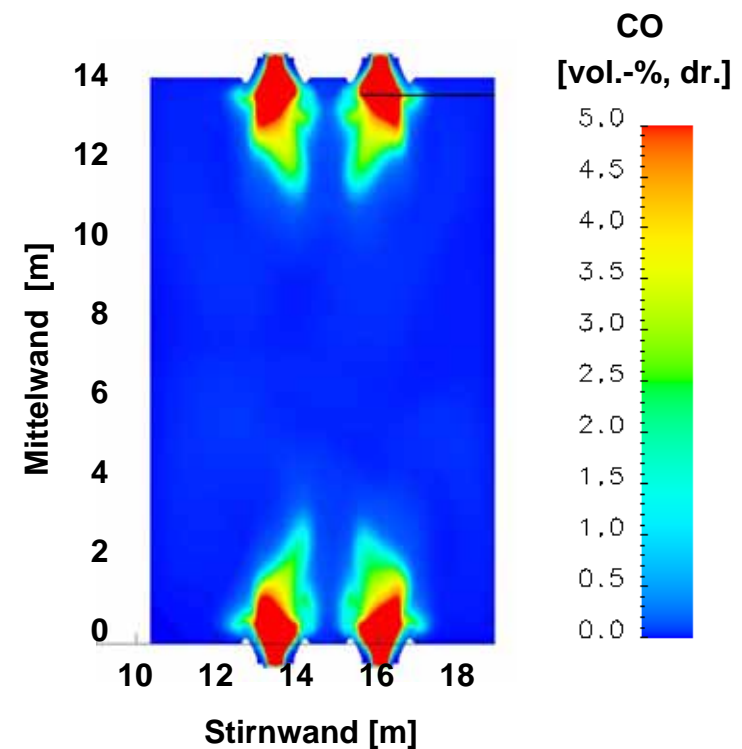
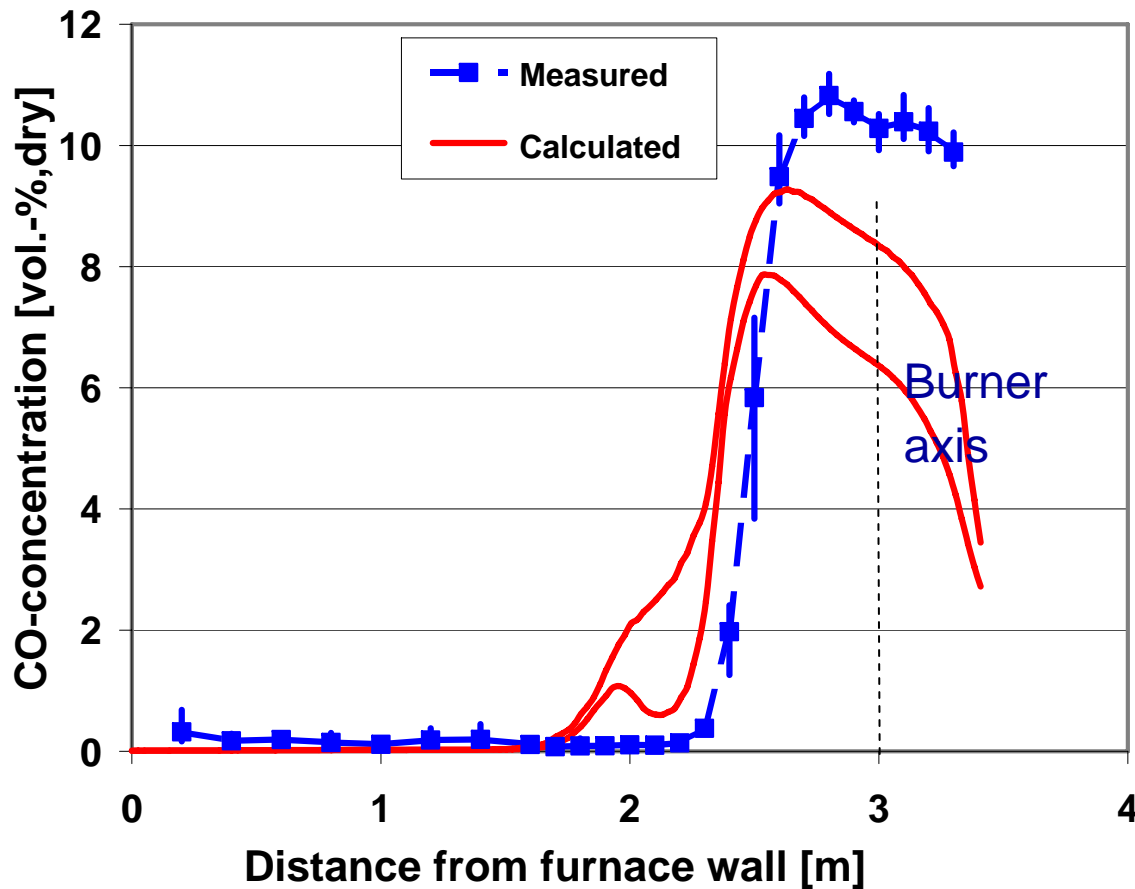
Burner Level 4 (31,2 m) 0,44 m Distance from rear wall





Example: Reliable CO-Predictions in front of the burner

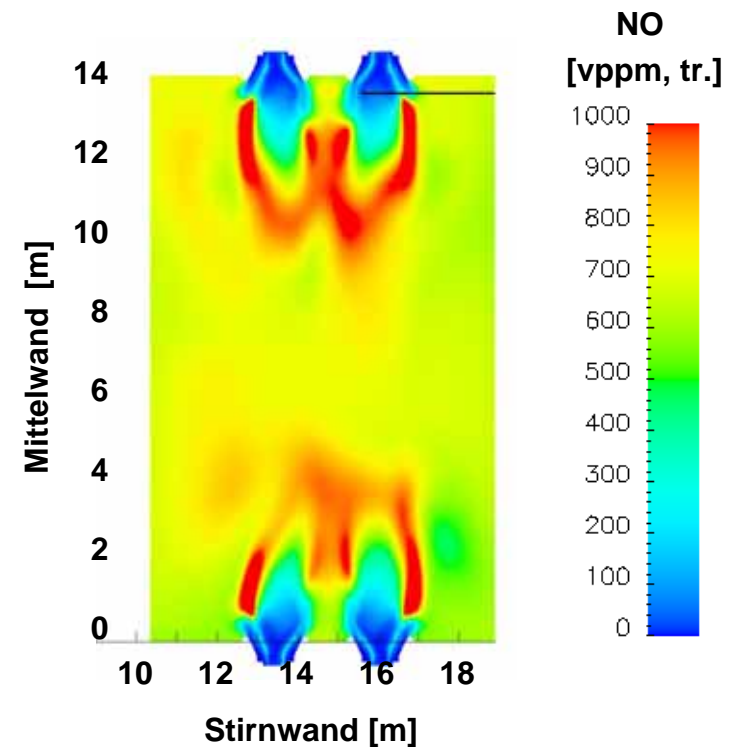
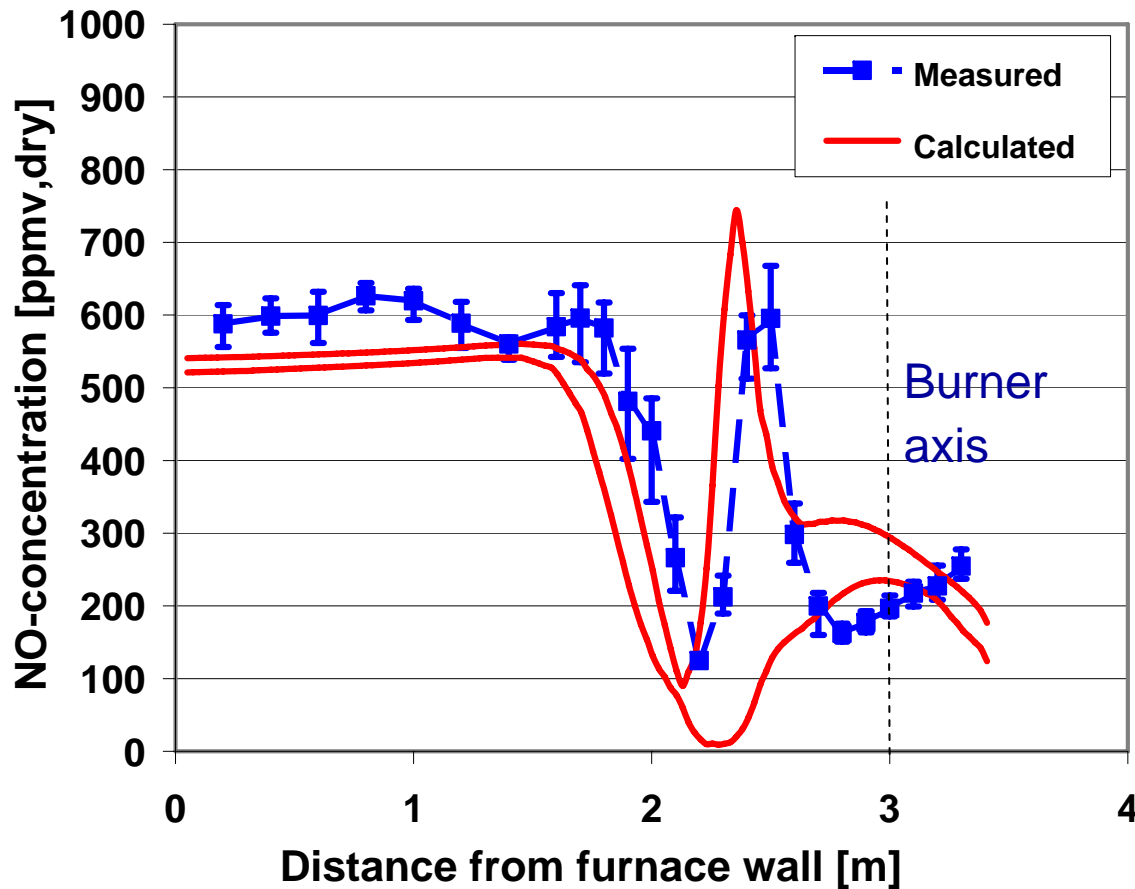
Burner Level 4 (31,2 m) 0,44 m Distance from rear wall





Example: Reliable NO-Predictions in front of the burner

Burner Level 4 (31,2 m) 0,44 m Distance from rear wall





Reliable prediction of boiler exit values

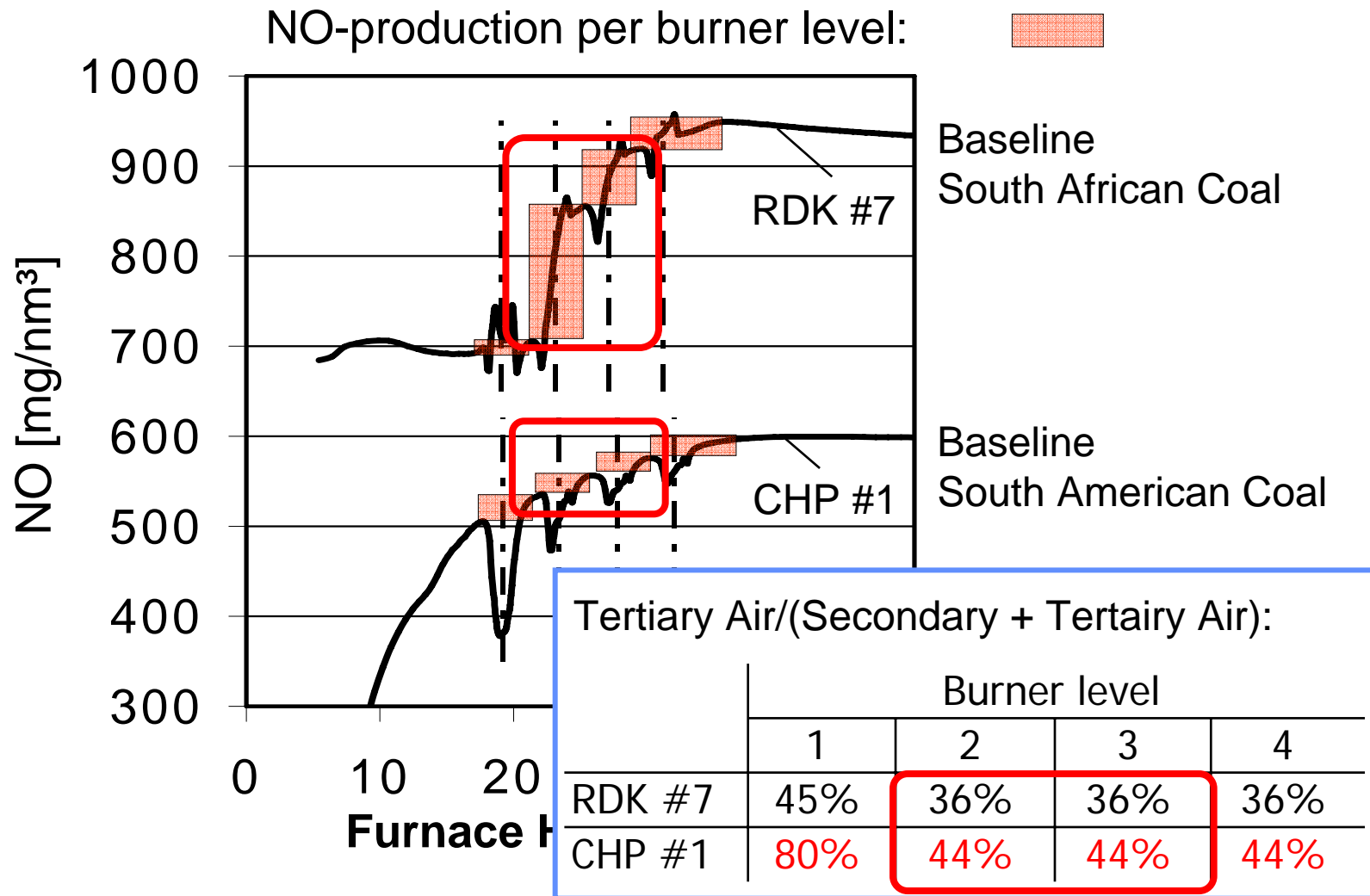
	Simulation	Measurements		
	Average	Minimum	Average	Maximum
Excess-O ₂ [Vol.%,dry]	3,97	3,58	3,93	4,24
NO _x [mg/Nm ³ , 6%O ₂]	1255	1112	1208	1280
CO [mg/Nm ³]	8,0	8,3	12,5	16,5
C in Ash [%]	2,1	2 – 3		



**„The predictions with RECOM-AIOLOS show
a good agreement with experimental data“**



Analysis of NO-production over furnace height





Validation of model predictions

Increased tertiary air in 2005 for	Level 2-3 Measured	Level 2-3 Simulation*	Level 2-4 Measured	Level 2-4 Simulation*
O ₂ [Vol.%,tr.]	4,17	4,15	4,17	4,16
NO _x [mg/Nm ³ , 6% O ₂]	1077	1088	989	1026
CO [mg/Nm ³]	11,5	13,5	9	12,5
NO _x -Reduction [mg/Nm ³ , 6% O ₂]	-131	-167	-219	-229

* Coal dust/ particle size distribution considered in the boiler model

➔ Total NO_x-Reduction: ca. - 219 mg/Nm³, 6% O₂

➔ Savings of ca. 780 t_{NH3} / Year



RECOM & LABORELEC successful modeling projects

Unit	Problem
Langerlo #1	Fuel switching and analysis of impact on combustion performance, wall corrosion, slagging/fouling
Ruien #5	Optimisation of burner design for a Syngas/coal co-firing situation
Centrale Gelderland	Feasibility study for a Syngas/coal co-firing scenario
Rodenhuize #2	Combined fireside/steamside modelling for the analysis of minimum load operation (Fuel: Blast Furnace Gas & Heavy Fuel Oil)
Kallo #2	Combined fireside/steamside modelling for the analysis of minimum load operation (Fuel: Natural Gas & Heavy Fuel Oil)
Langerlo #1	Combined fireside/steamside modelling for the analysis of the impact of a burner retrofit together with co-firing wood dust and palm oil
Rodenhuize #4	Combined fireside/steamside modelling for the analysis of the impact of design changes and fuel changes on combustion performance (Fuel: Blast Furnace Gas, Coal, Wood Pellets, Olive Residue)
Polaniec #2 & #4	Combined fireside/steamside modelling for the analysis of the impact of design changes and fuel changes on combustion performance (Fuel: Coal, Biomass/Fresh Wood)



Summary

- ➔ In the past years RECOM has performed 52 baseline simulations with comparison between field measurements and model predictions, and simulated 440 boiler variations
- ➔ The RECOM boiler model data base has around 60 boiler models
- ➔ RECOM boiler models are used now to predict the performance of completely new boiler designs that have never been built before.
- ➔ Feedback on the reliability of these predictions will be available within a couple of years.
- ➔ Final Goal is to build thousands of Power Plants in the virtual reality to improve the optimization level of these systems.