47th International Energy Agency
Workshop on Large Scale CFB and Technical Meeting

Turow Power Station, Zlotniki, Poland October 13th and 14th 2003

Testing and Simulation in Turow Unit 3 and the Application of the Results on the Lagisza 460 Mw_e OT CFB

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Foster Wheeler

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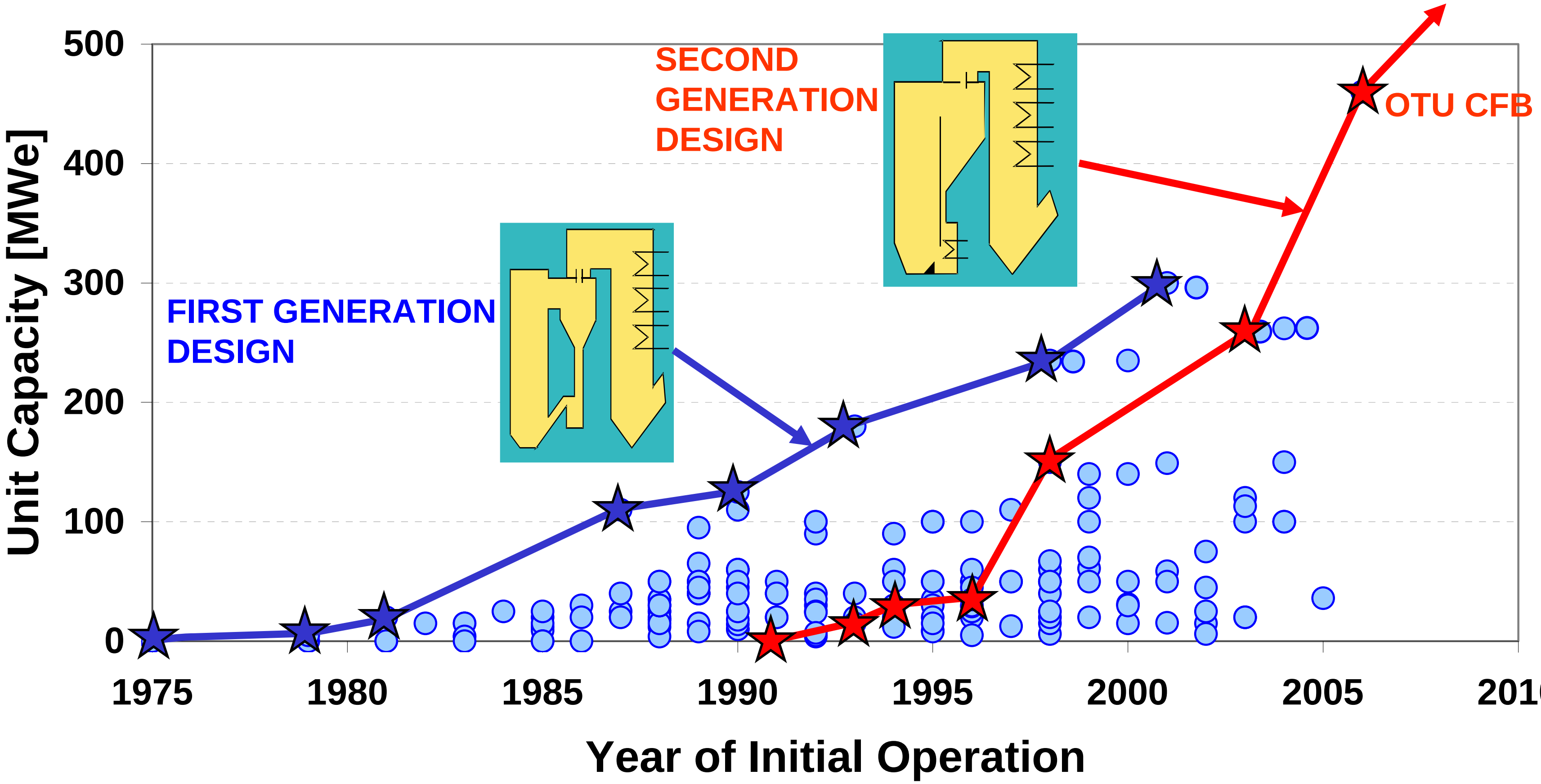
Background for CFB Models

- Trends for CFB boiler industry:
  - Larger unit sizes and higher steam parameters.
  - Higher efficiency.
  - Tighter emission standards.
- More detailed, fast and reliable models required.
- Valid model – optimised CFB design and process performance.

Power Output of Foster Wheeler CFB Units



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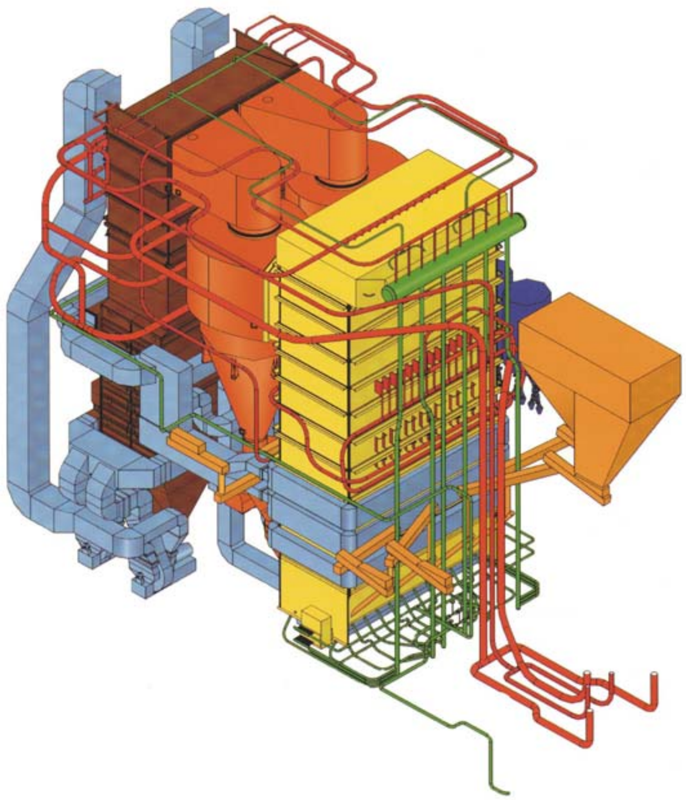
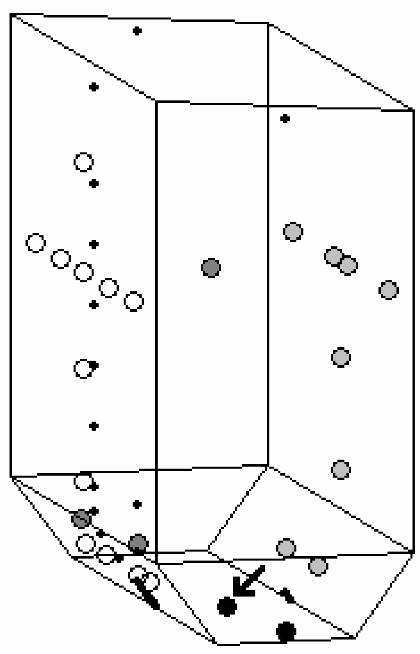
PROCESS MEASUREMENTS IN TUROW UNIT 3

EU PROJECT: Processes In Large-scale Circulating Fluidized Bed Combustors

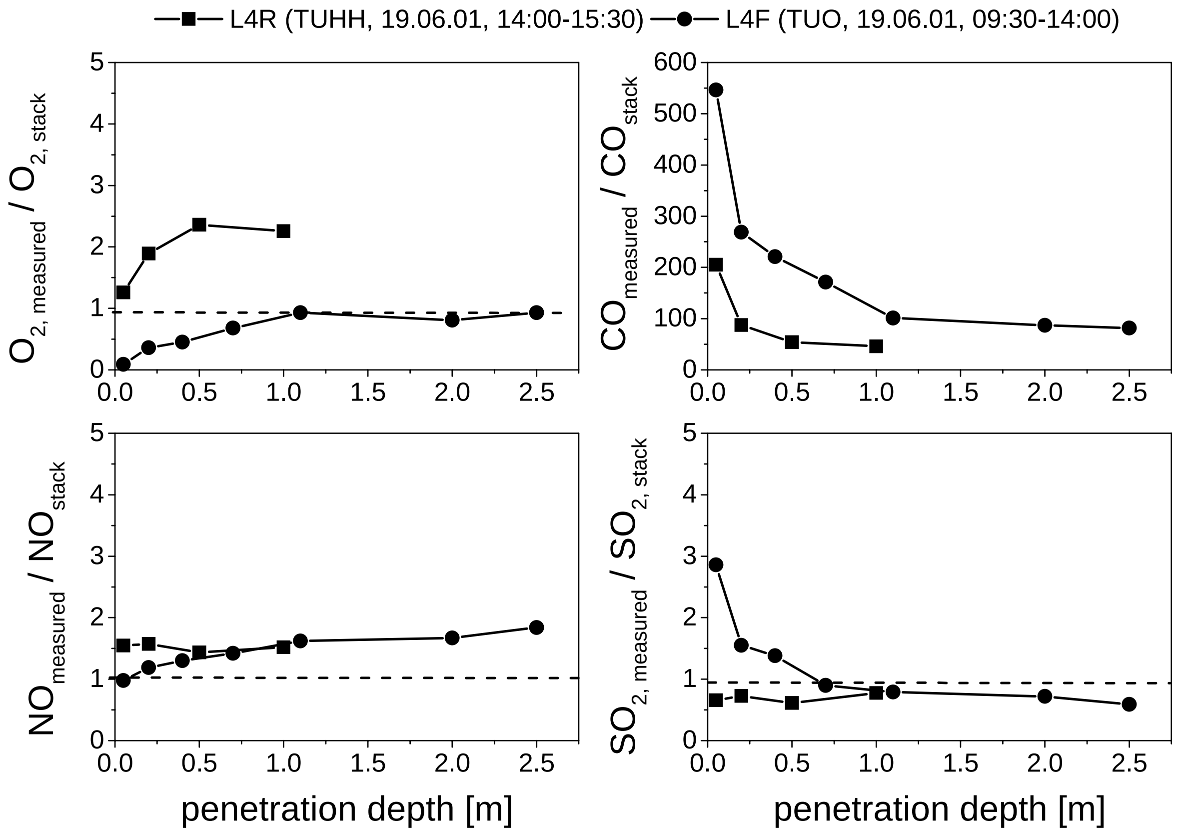




- gas concentration
- solids distribution
- temperature distribution
- solids flow
- solids segregation

PROCESS MEASUREMENTS IN TUROW UNIT 3

Gas concentrations



DESIGN MODEL FOR THE CFB HOT LOOP

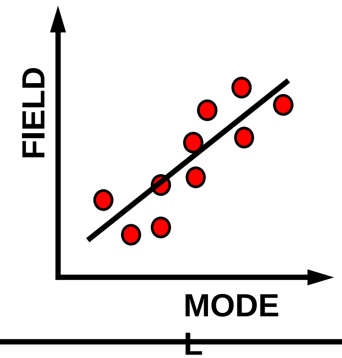
CFB DATABASE
- Field tests and analyses

CHARACTERIZATIO N
- Fuel & Limestone
- Reactivity

NEW FUEL

CFB DESIGN MODEL

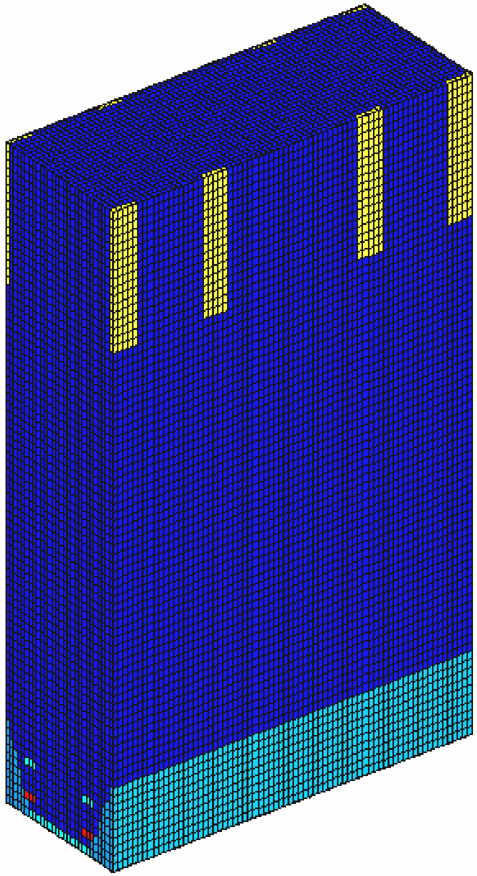
PARAMETERS
- Solids loading
- Heat transfer
- Emissions
- ...



BOILER DESIGN PERFORMANCE

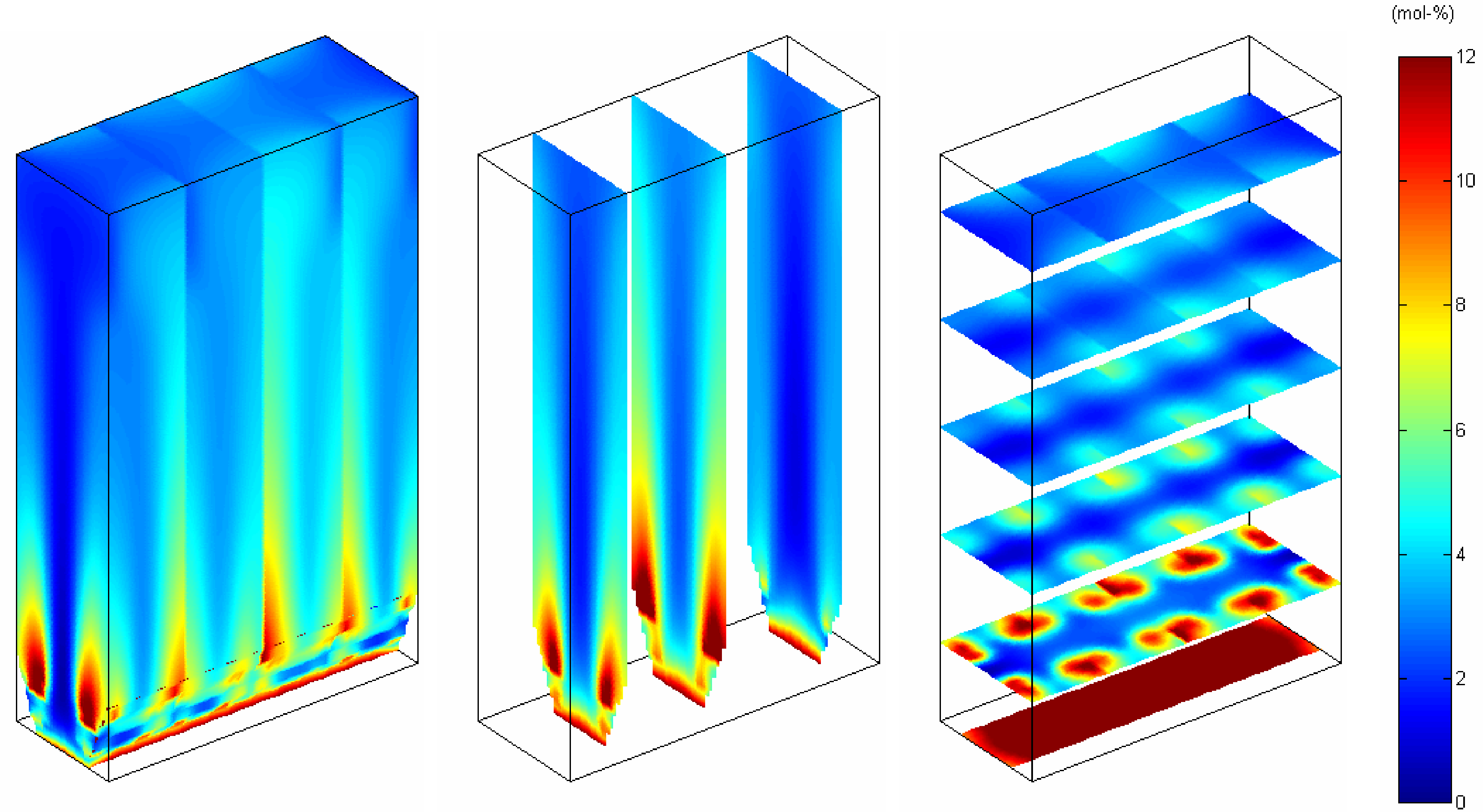
Model Description

- Steady-state combustion model for CFB furnace.
- 0-D fractional material balances.
- 3-D modeling of solid and gaseous species.
- 3-D modeling of energy balance.
- Empirical suspension density profile.



Calculation Results

Oxygen



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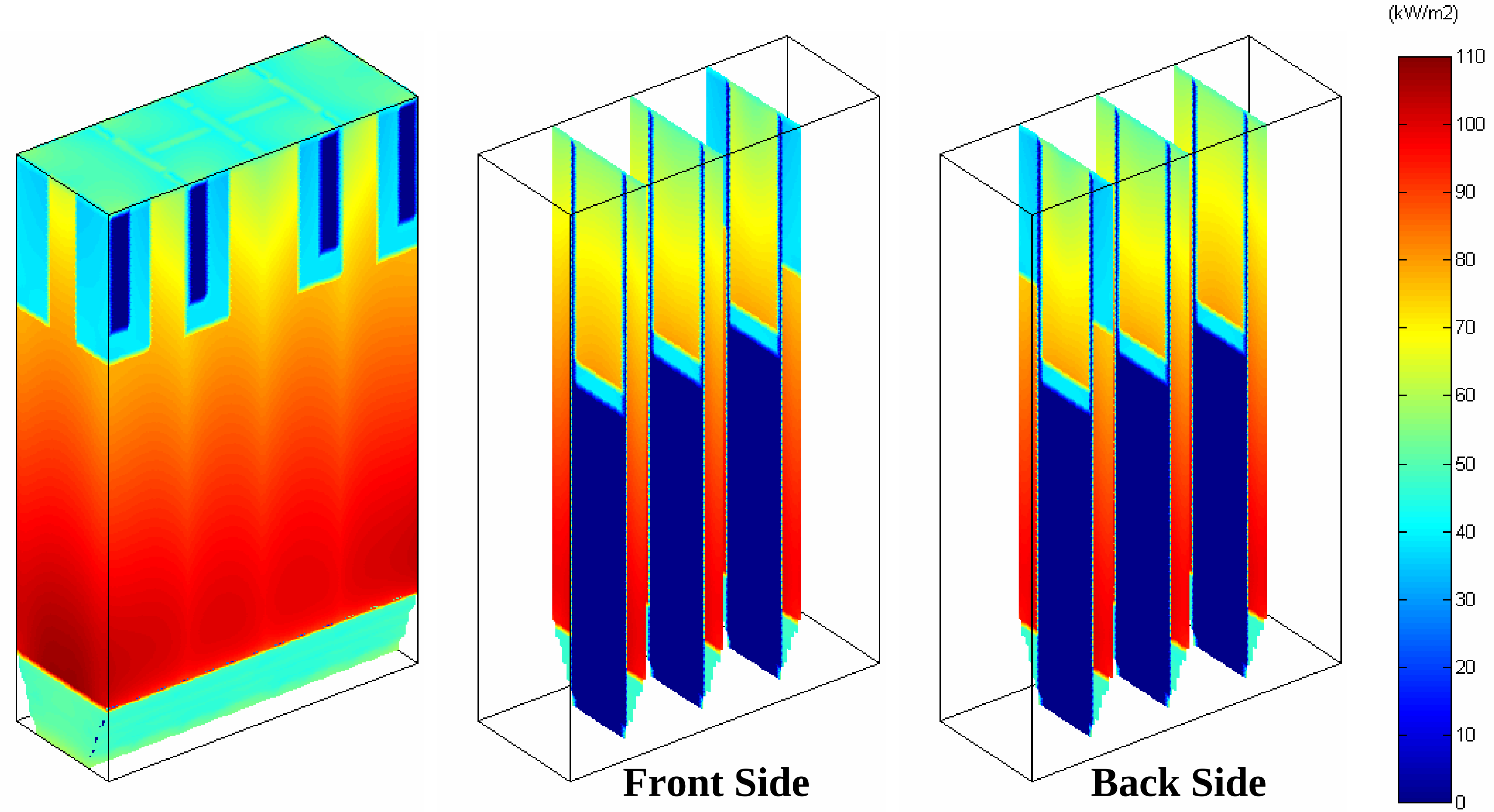
Calculation Results

Heat Flux



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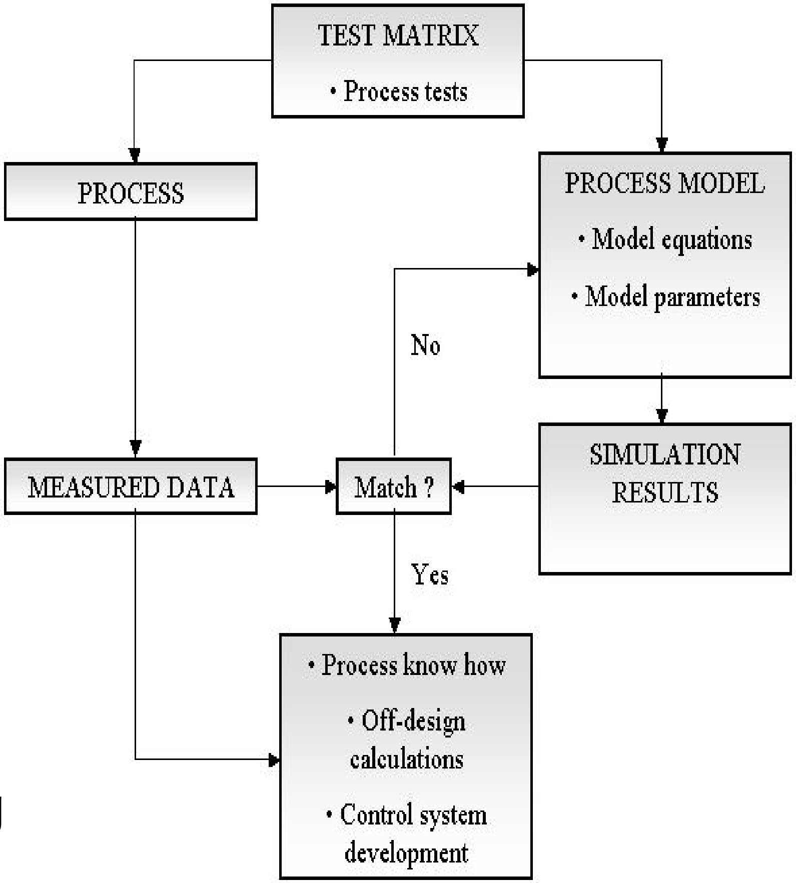
Simulation Tools
The Dynamic CFB Model of Foster Wheeler

- A dynamic simulation tool to model dynamic behavior of the CFB system.
- Separate submodels have been developed for different parts of the CFB loop
  - Furnace
  - Solids separator
  - Return channel
  - INTREX™ heat exchangers.
- Each model component is based on the fundamental laws of conservation of mass, energy and momentum and on empirical correlations.

Analysis of Process Dynamics

- **Dynamic Process Tests**
  - **Dynamic process tests have been carried out in a 235 MW$_e$ CFB boiler.**
- **Process Modeling**
  - **A tailored dynamic simulator was built for the 235 MW$_e$ CFB boiler.**
- **Model Validation and Simulation Analysis**
  - **Measured data on the dynamic process tests were used to determine and to verify the model parameters and modeling principles.**



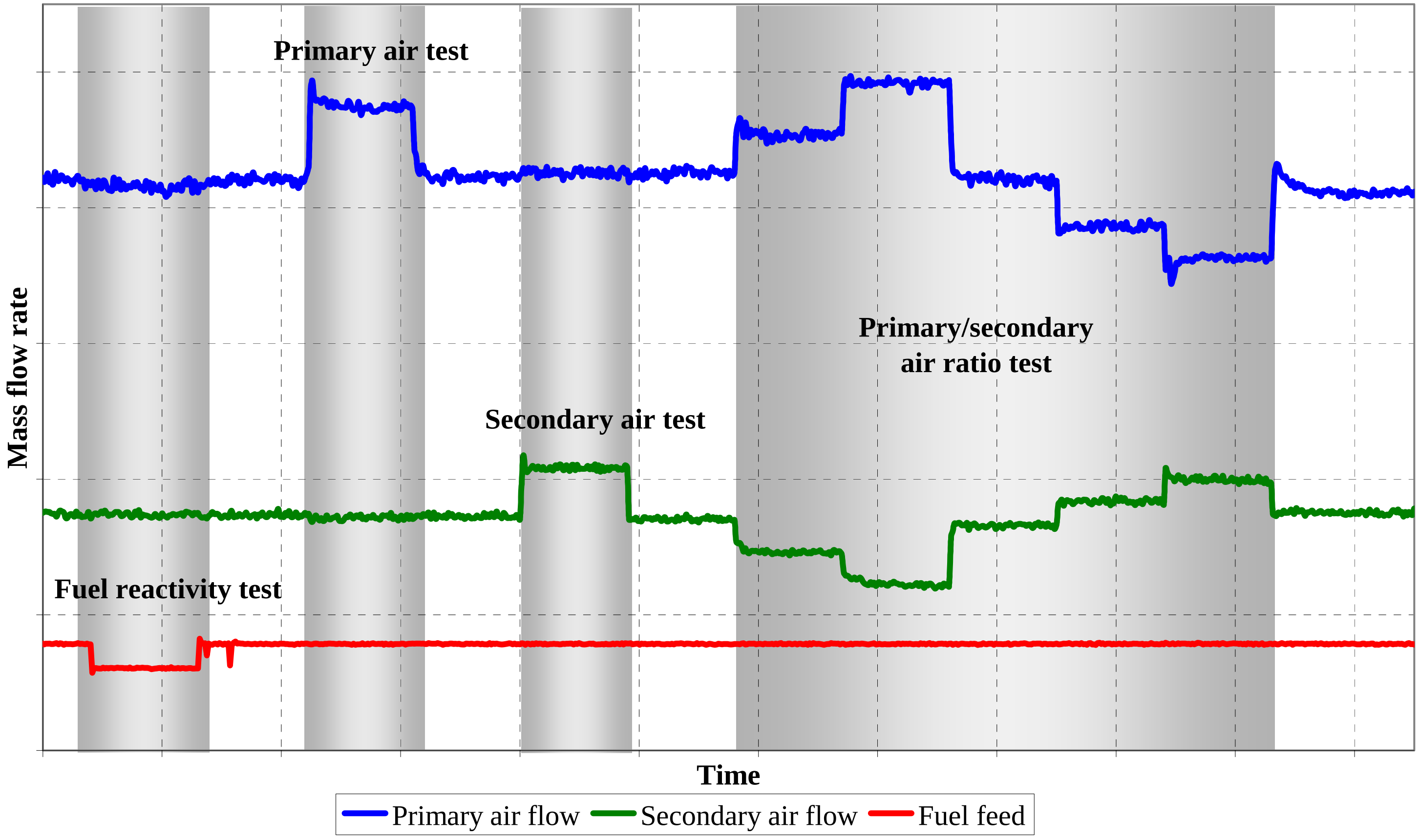
Analysis of Process Dynamics
Dynamic Process Tests

Matrix of the Dynamic Process Tests

Test	*Load 100 %*	*Load 80 %*	*Load 60 %*	*Load 40 %*
Open loop load change	100 ⇒ 90 ⇒ 80	80 ⇒ 70 ⇒ 60 80 ⇒ 90 ⇒100	60 ⇒ 50 ⇒ 40 60 ⇒ 70 ⇒ 80	40 ⇒ 50 ⇒ 60
closed loop load change	100 ⇒ 80 4 %/min	80 ⇒ 60 80 ⇒ 100 4 %/min	60 ⇒ 40 60 ⇒ 80 4 %/min	40 ⇒ 60 4 %/min
Fuel reactivity	+/- 10 % step change	+/- 10 % step change	+/- 10 % step change	
Primary air	+/- 10 % step change	+/- 10 % step change	+/- 10 % step change	
Secondary air	+/- 10 % step change	+/- 10 % step change	+/- 10 % step change	
Prim/sec air ratio	60/40 ⇒ 65/35 ⇒ 70/30 ⇒ 60/40 ⇒ 55/45 ⇒ 50/50 ⇒ 60/40	60/40 ⇒ 65/35 ⇒ 70/30 ⇒ 60/40 ⇒ 55/45 ⇒ 50/50 ⇒ 60/40	60/40 ⇒ 65/35 ⇒ 70/30 ⇒ 60/40 ⇒ 55/45 ⇒ 50/50 ⇒ 60/40	

Analysis of Process Dynamics

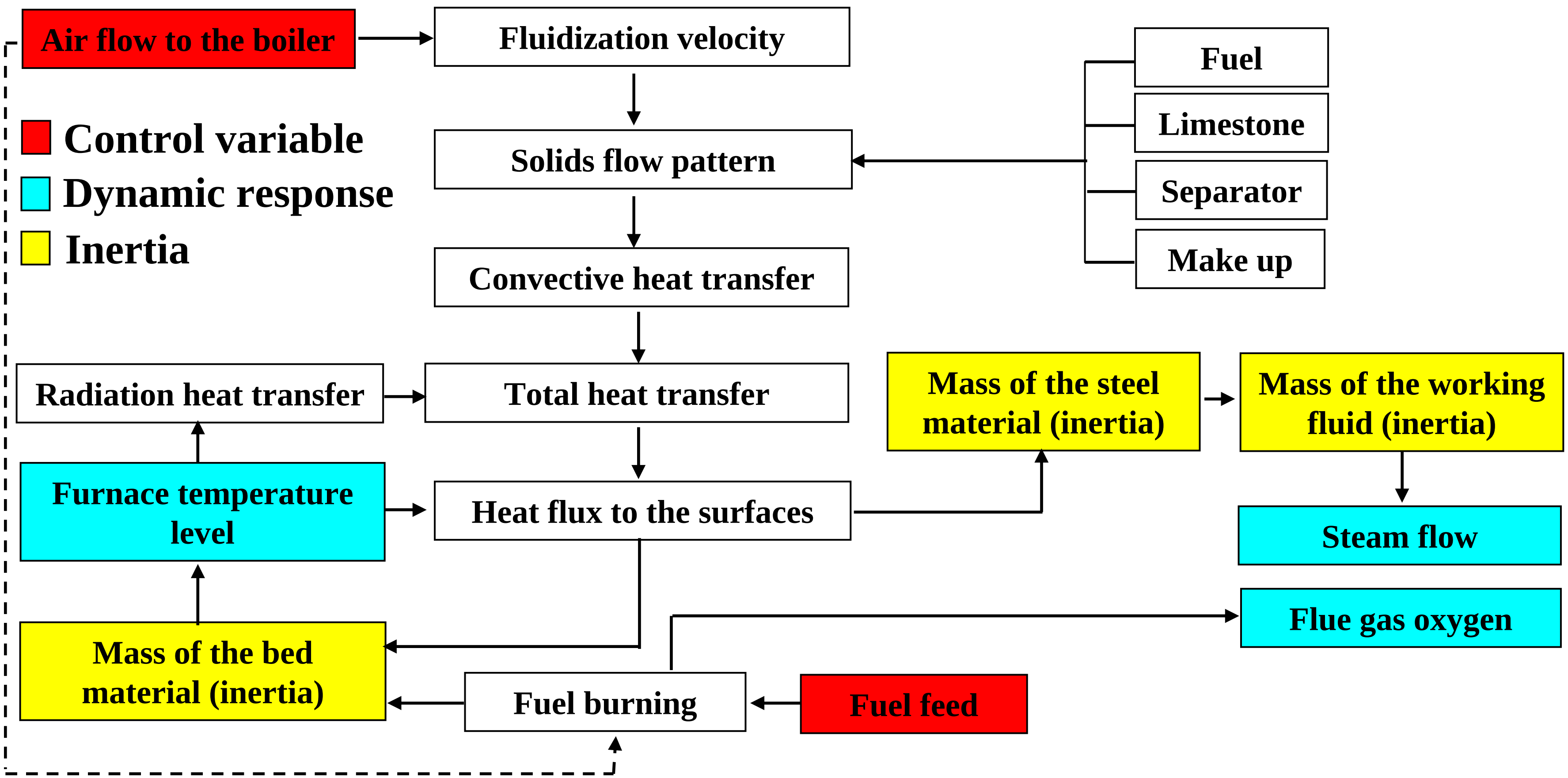
Dynamic Process Tests



Execution of the Dynamic Process Tests

Analysis of Process Dynamics

Basics of the CFB Dynamics



HIPE CFB

High Performance Multifuel CFB with Advanced Steam Cycle

- EU – funded research program (2001 – 2003)
  - Total volume 3.6 M€ (1.7 M€ from EU)
- Objective
  - Development of Supercritical Once Through Design for Circulating Fluidized Bed (CFB) Boiler
- Partners
  - Foster Wheeler Energia OY
  - Siemens AG
  - Energoproject Katowice
  - Technical Research Center of Finland

Lagisza Power Station, 460 MW_e, Poland

CFB BOILER DESIGN DATA

Output	**MW_e**	**460**
Steam Flow	**kg/s (SH/RH)**	**360/313**
Steam Pressure	**bar (SH/RH)**	**275/50**
Steam Temperature	**°C (SH/RH)**	**565/580**

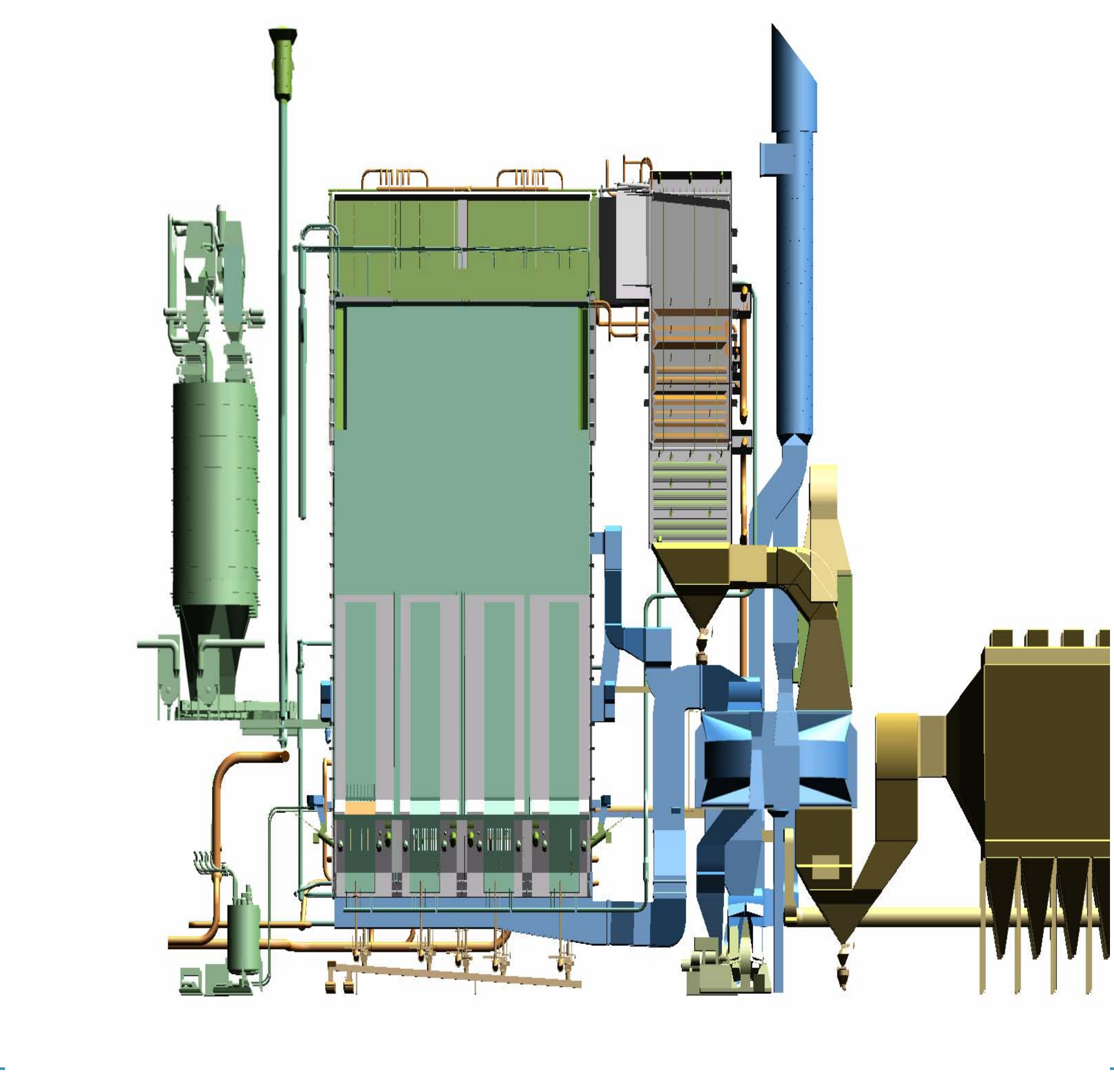
SCHEDULE

Contract Signing	**December 30, 2002**
Engineering Release	**March 1, 2003**
Mechanical Completion	**February 28, 2006**
Commercial Operation	**September 30, 2006**

FUELS (as received)

		Coal		Coal Slurry (max. 30 %)
		Performance	Range	Range
Sulphur	**% wt**	**1.2**	**0.6 – 1.4**	**0.6 – 1.6**
Ash	**% wt**	**23**	**10-25**	**28-65**
Moisture	**% wt**	**12**	**6-23**	**27-45**
LHV	**MJ/kg**	**20**	**18-23**	**7-17**

ŁAGISZA 460 MW_e CFB



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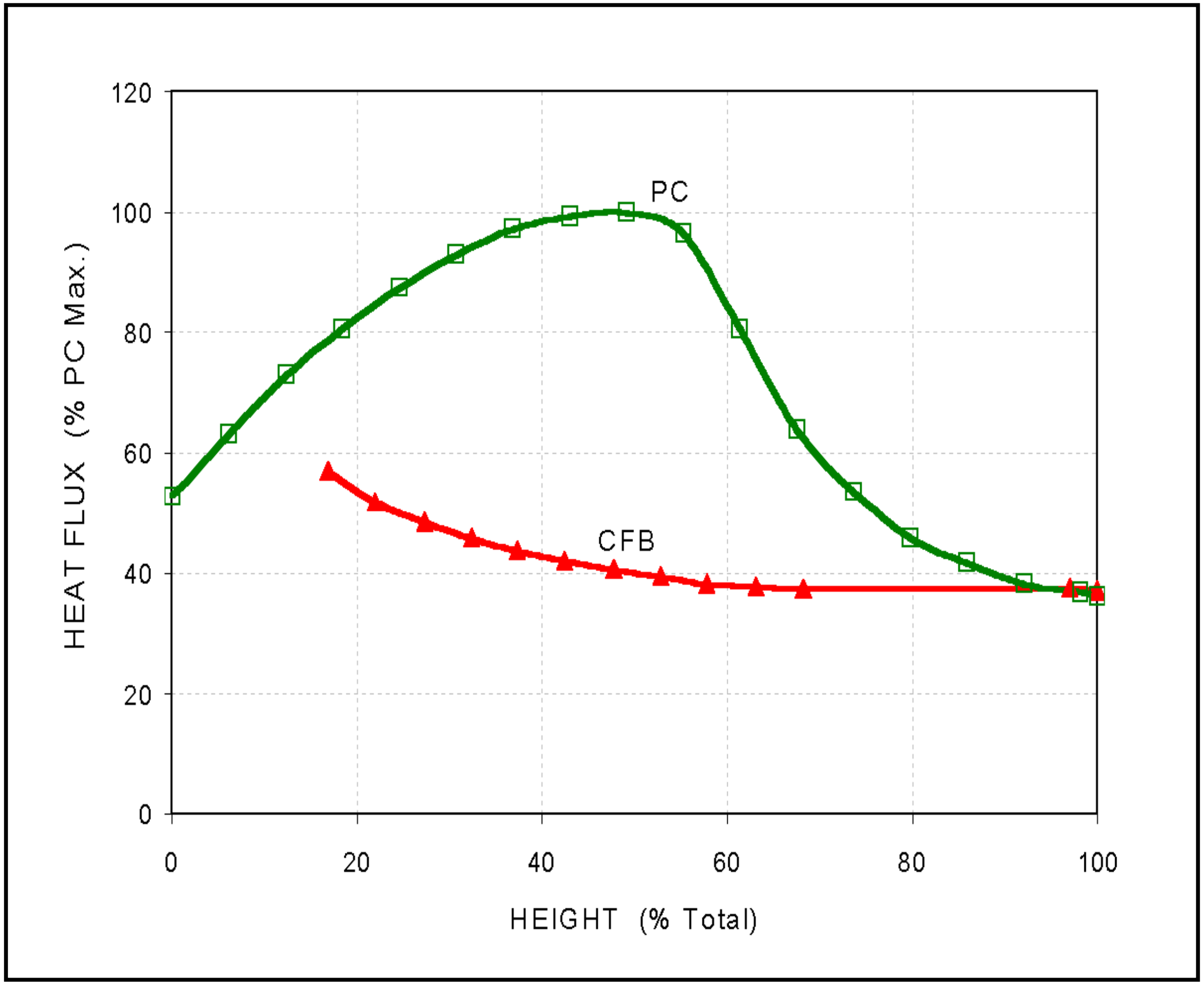
Lagisza: Evaporator Studies

- **Furnace calculated with Foster Wheeler's modern 3D furnace model**
- **Different design conditions evaluated**
  - **Furnace conditions**
  - **Evaporator water/steam side conditions**
  - **Example: Coal feeder disturbance**

HEAT FLUX COMPARISON



- Low and uniform heat fluxes in a CFB furnace
- Lower mass flow rates ("natural circulation characteristics")

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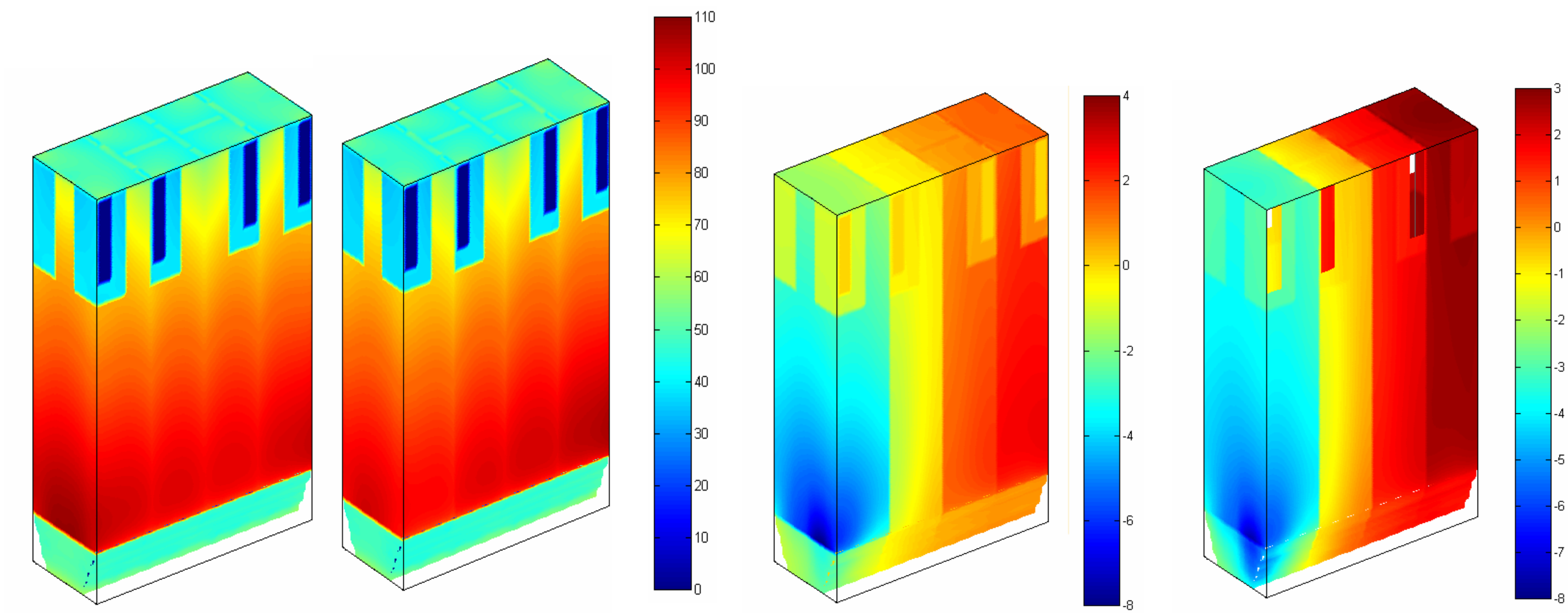
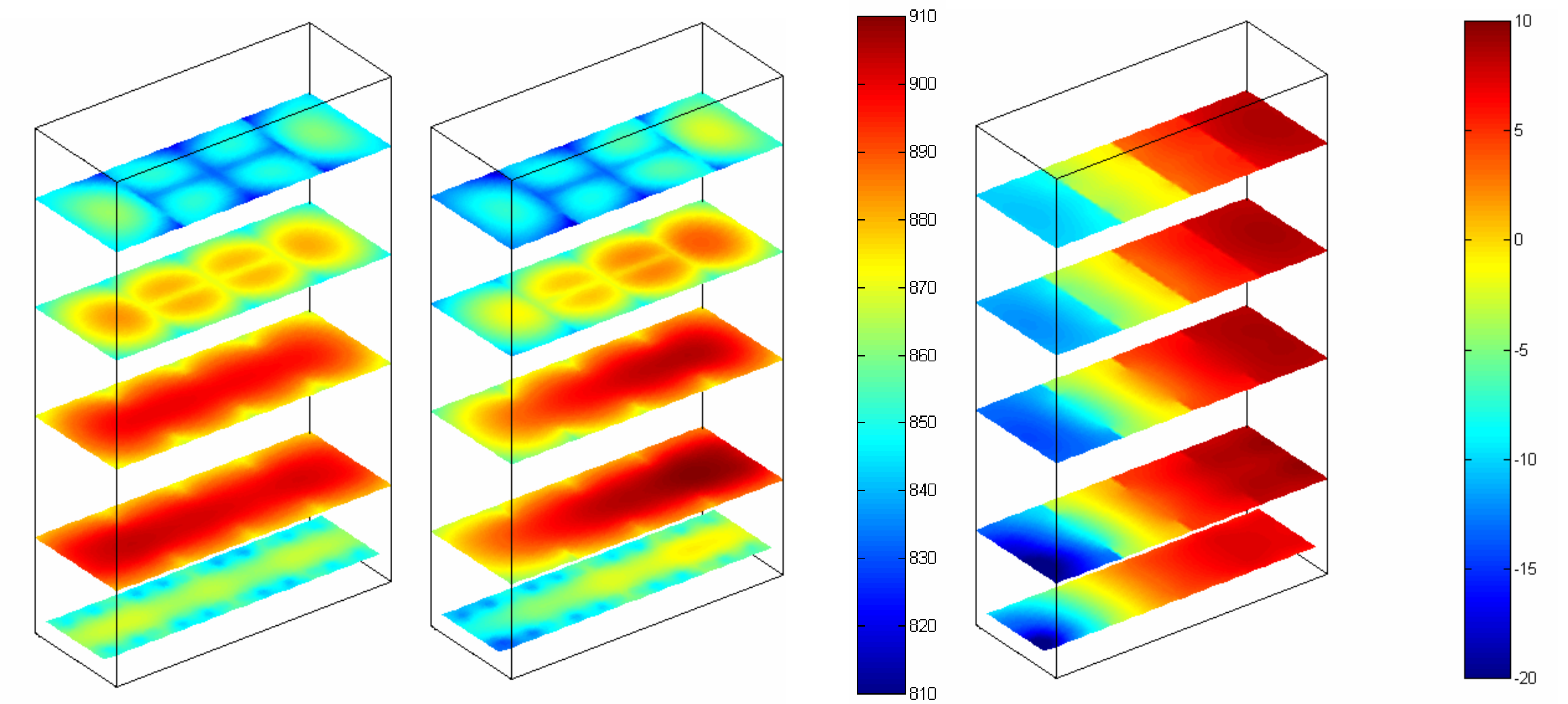
Furnace Heat Flux – Comparison of Two Cases



Case 1– Basic case. Uniform fuel feeding to all the feeding points.	**Case 2– Fuel feed stopped to feeding point at front-right corner. Feed rate to other feeders increased equally.**	**Scale [kW/m^2]**	**Difference Case 2 – Case 1 [kW/m2]**	**Percentual change [%]**

Furnace Combustion Temperature – Comparison of Two Cases



Case 1– Basic case. Uniform fuel feeding to all the feeding points.	**Case 2– Fuel feed stopped to feeding point at front-right corner. Feed rate to other feeders increased equally.**	**Scale [°C]**	**Difference Case 2 – Case 1 [°C]**	

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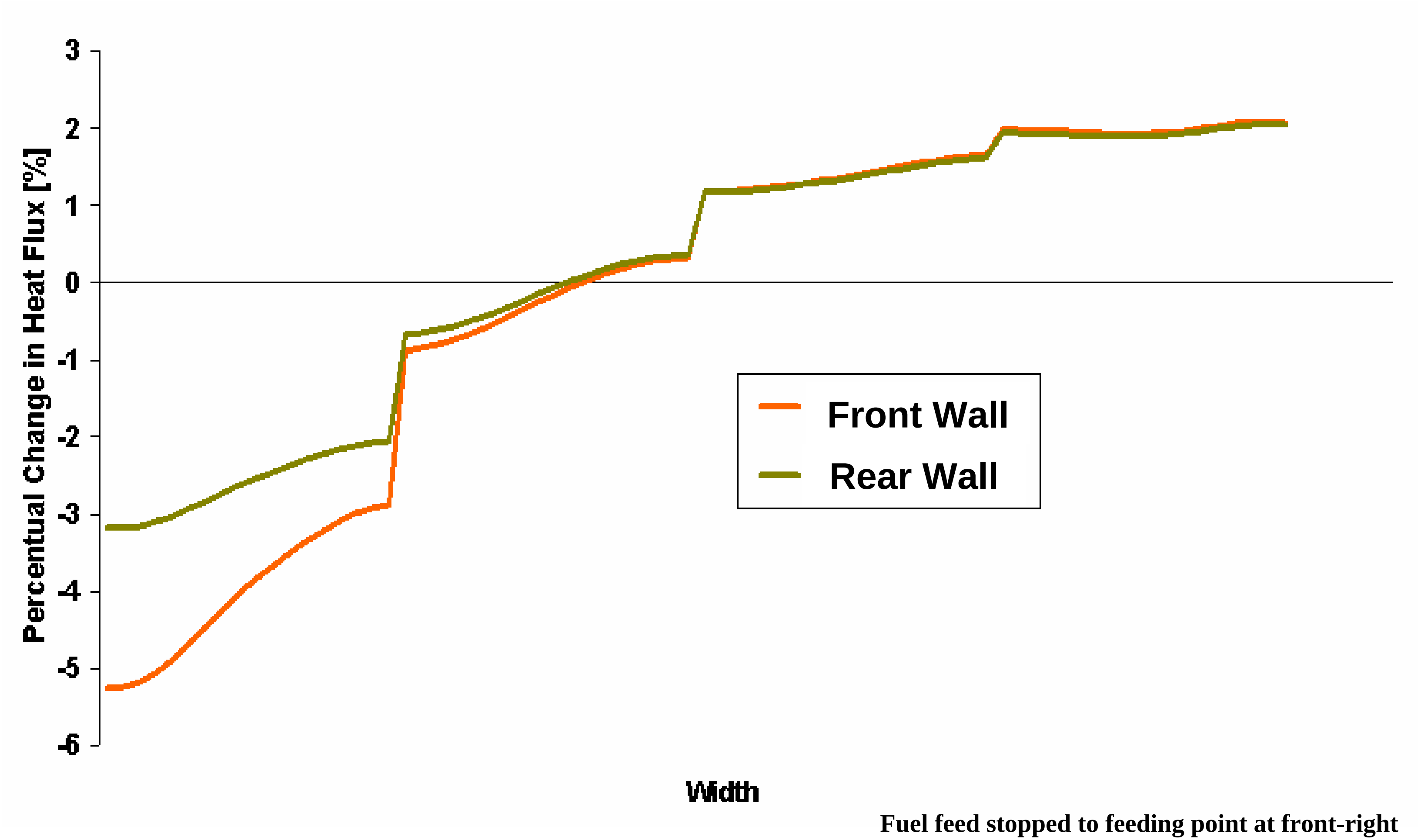
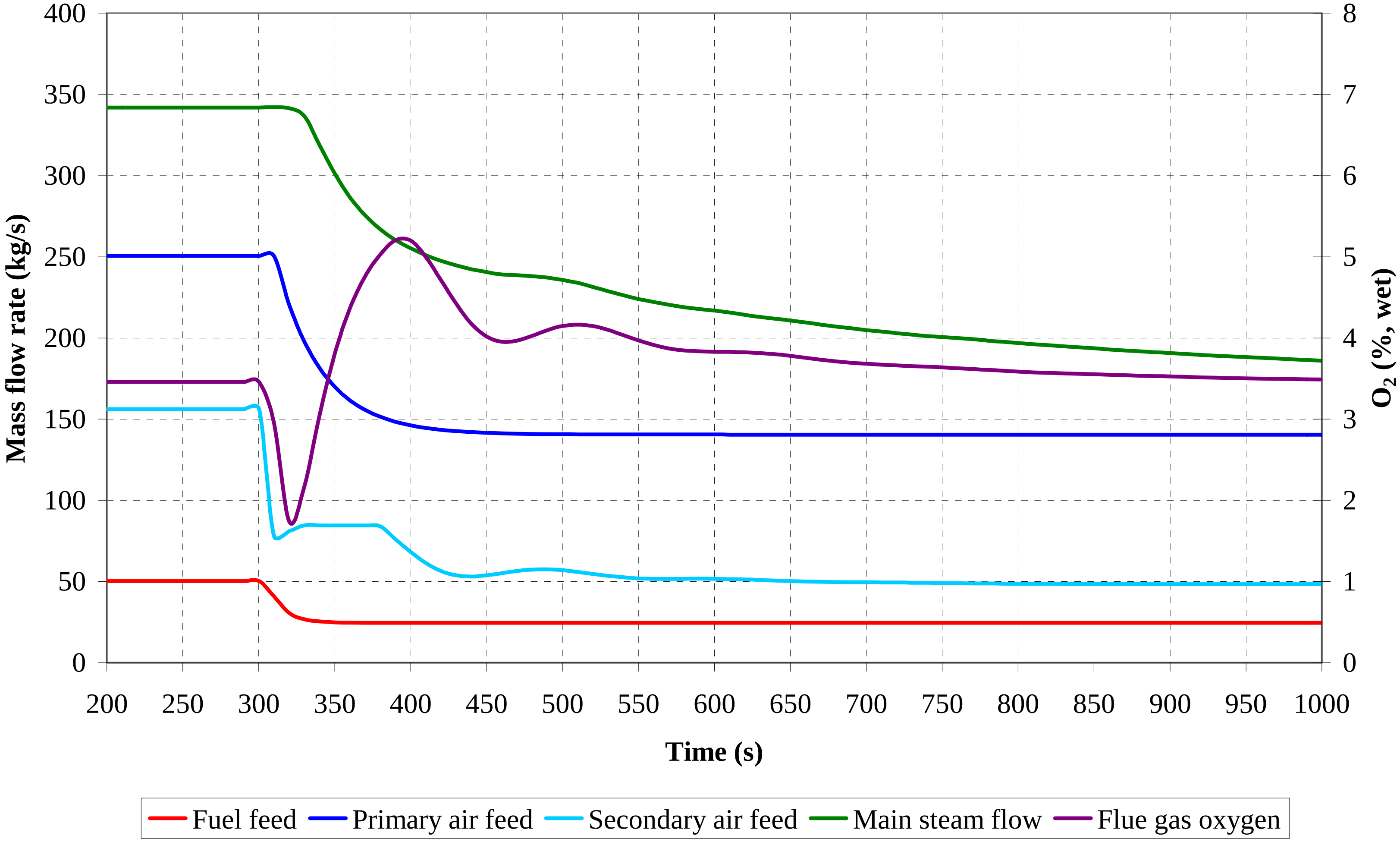
Heat Flux Difference Horizontally



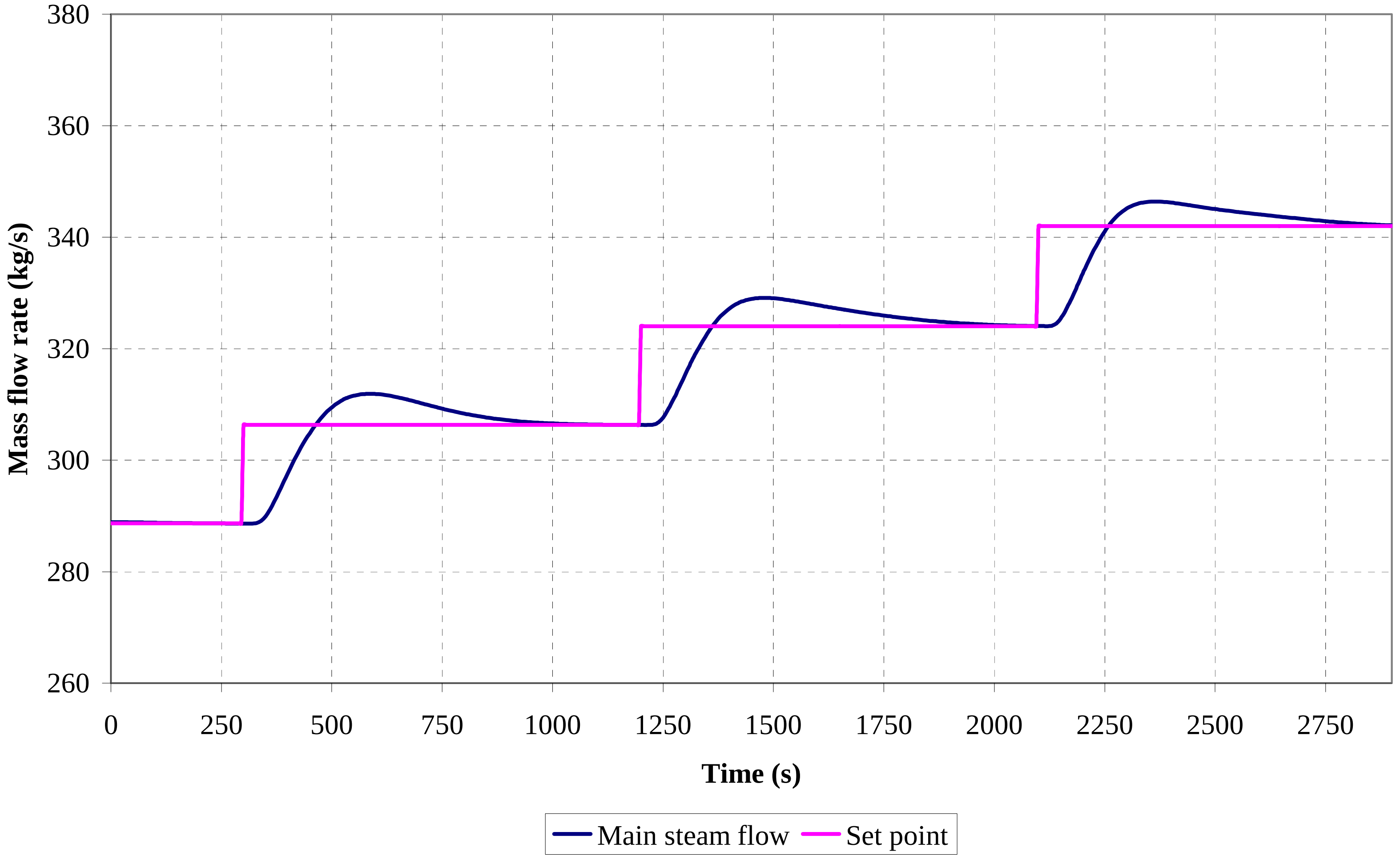
Fuel feed stopped to feeding point at front-right corner. Feed rate to other feeders increased equally.

Lagisza: Dynamic Simulations

Boiler run-back: Secondary air fan trip



Lagisza: Dynamic Simulations
Step load changes +5% MCR



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SUMMARY

Process tests in Turow produced valuable data for the modelling of large scale furnaces

The valid models are essential tools in further development of OT CFB (Lagisza)

The models are tools for the further optimisation of Turow units

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