# Model based control for advanced PID combustion controllers in WtE plants

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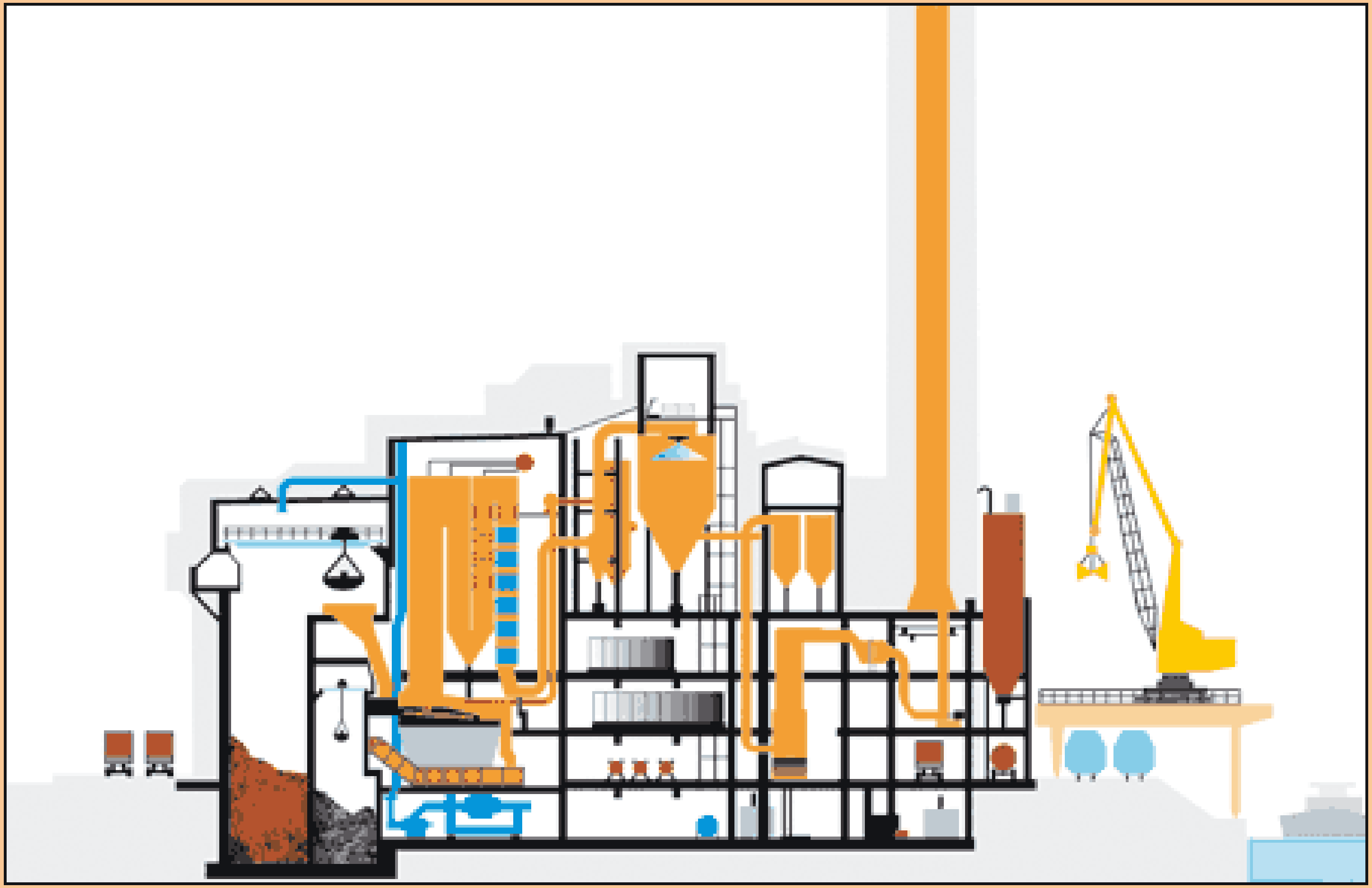
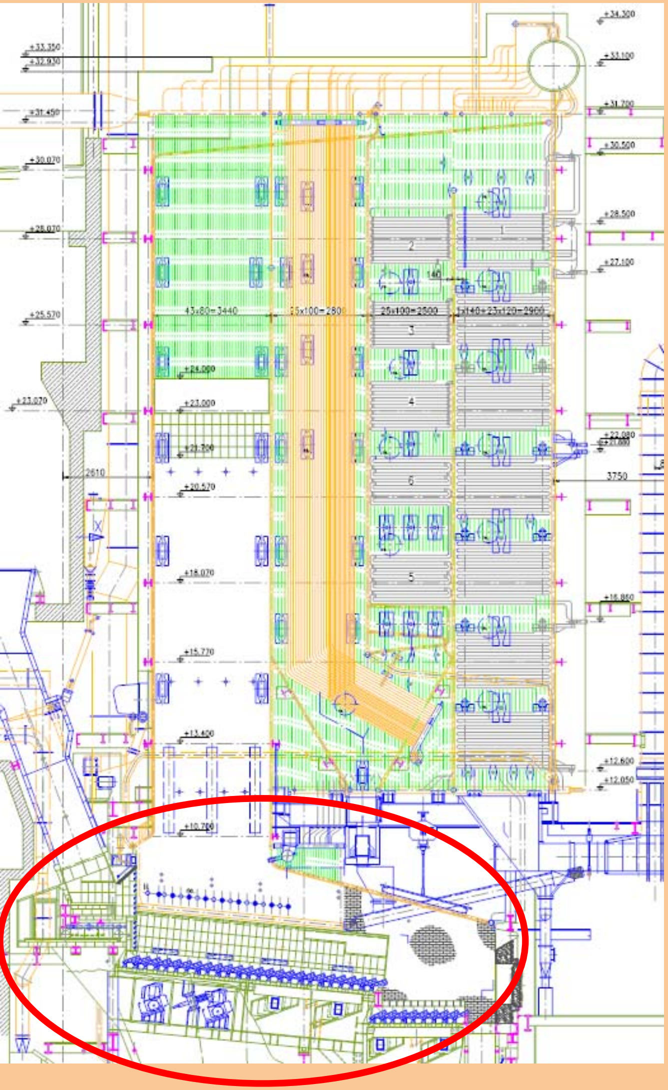
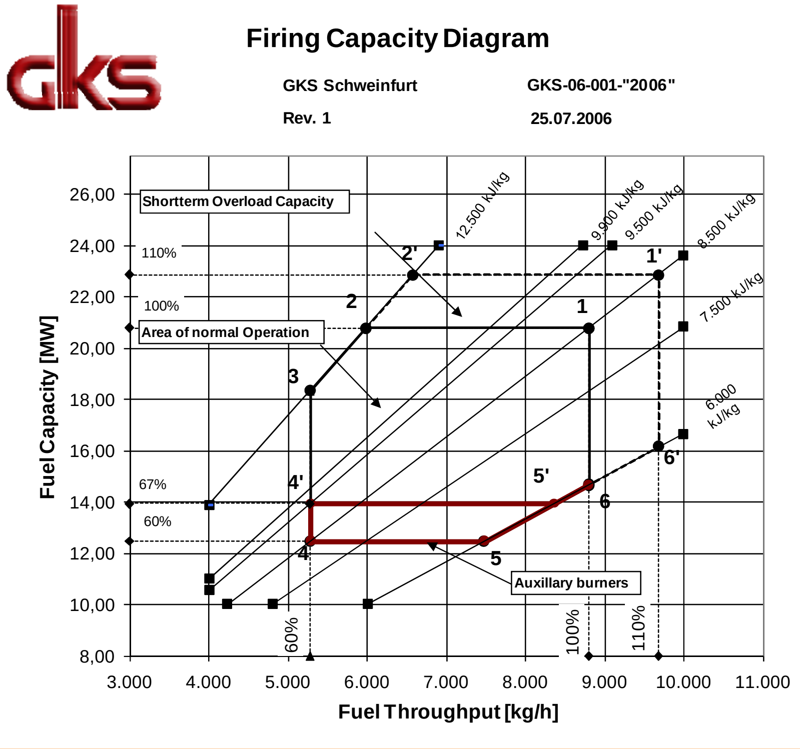
# GKS
# Gemeinschaftskraftwerk Schweinfurt GmbH
# - Waste-to-Energy Section -





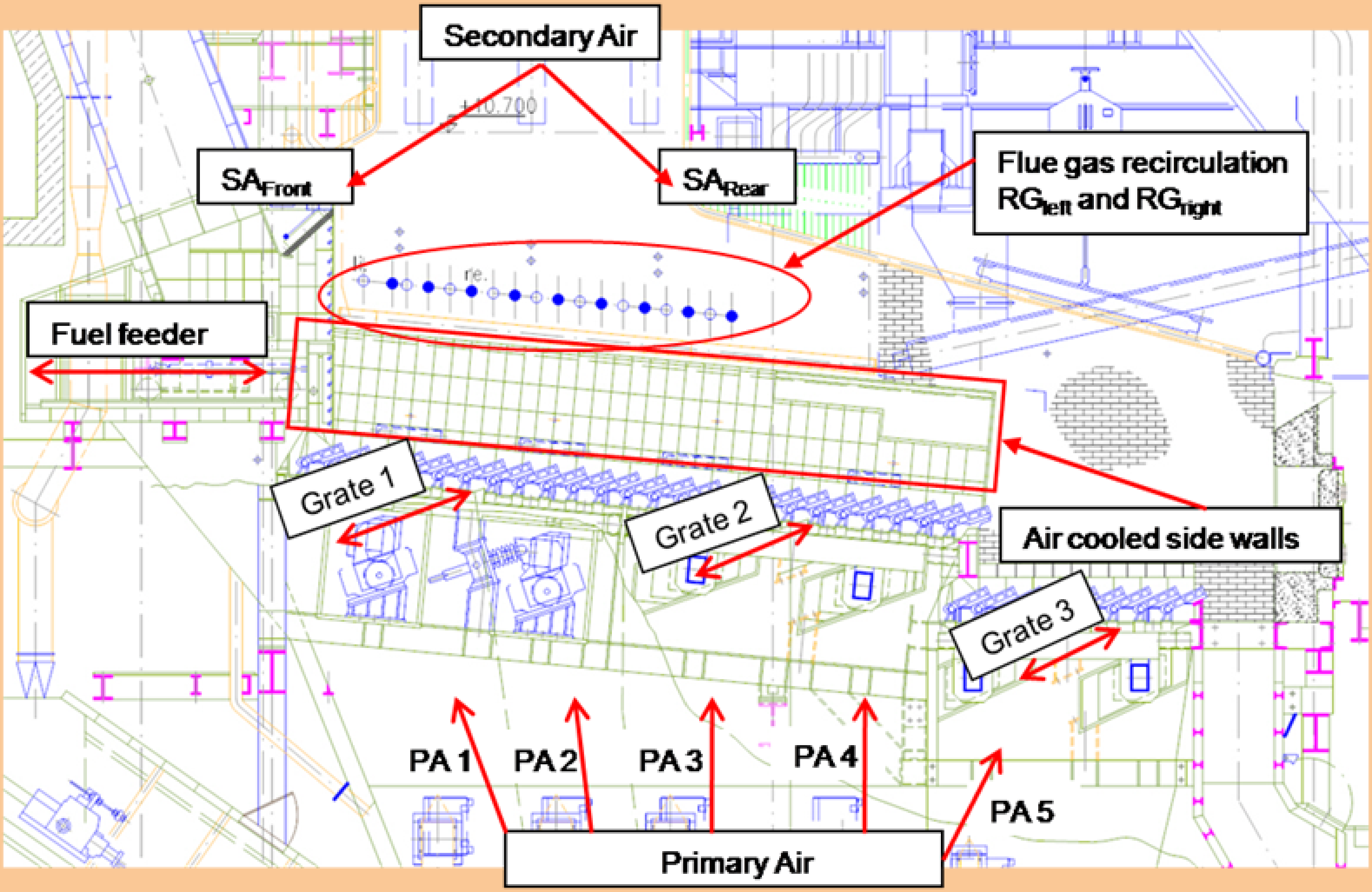



Important to meet the given capacity data

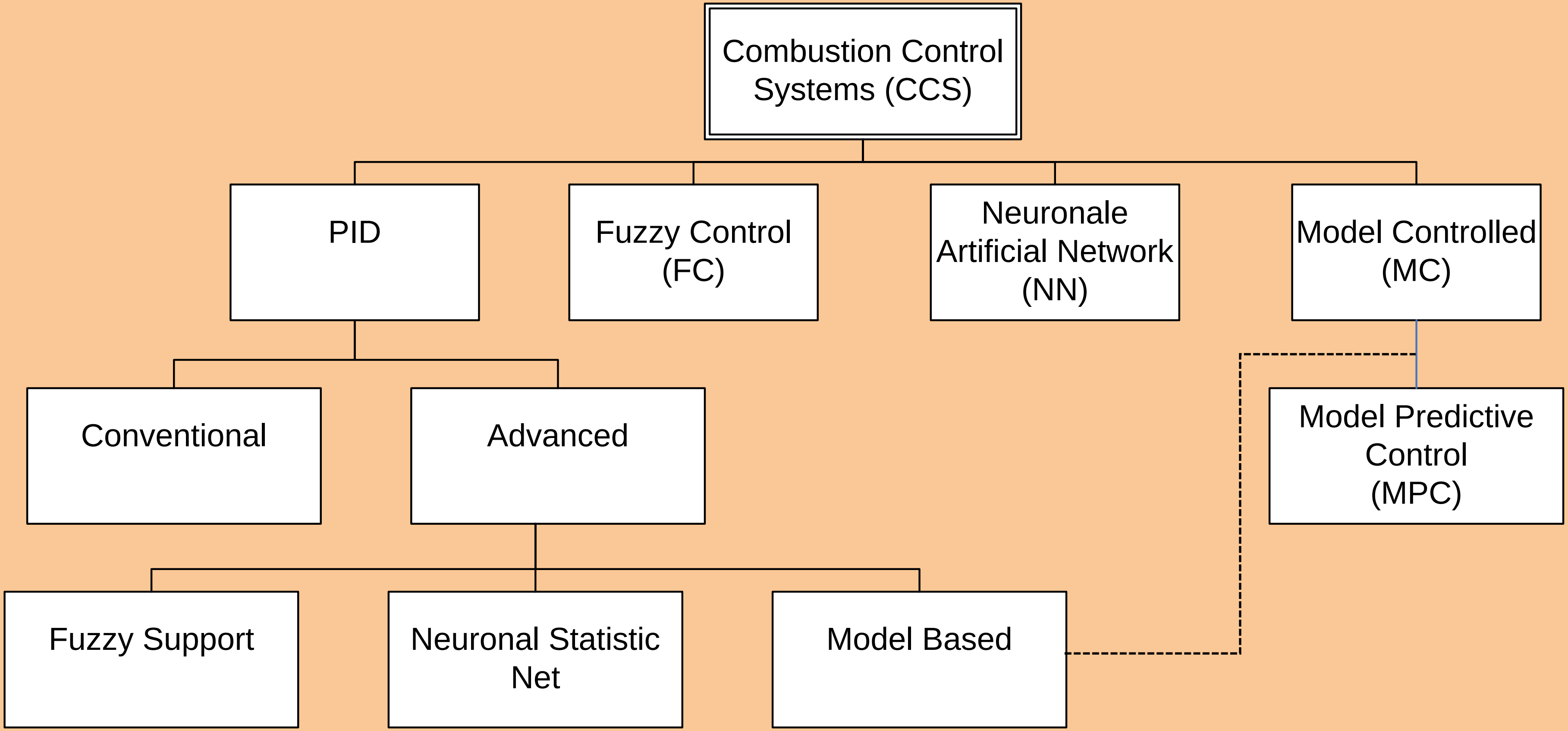
↓

Good combustion control system necessary

# Manipulable Variables: 18!



# Kinds of Combustion Control Systems

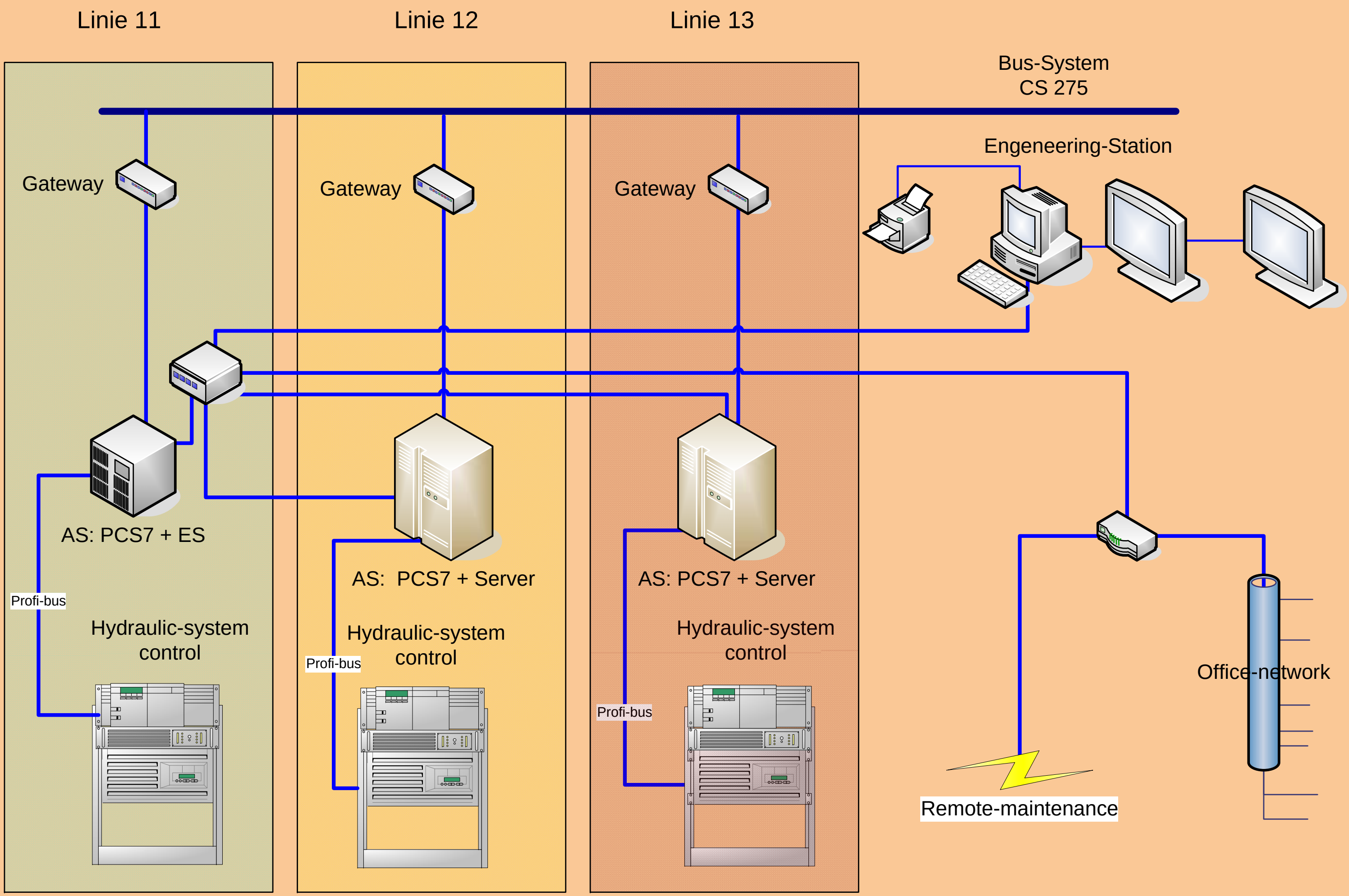


# Decision matrices

| Control systems:→ Arguments:↓ | PID | FC | NN | MPC |
|---|---|---|---|---|
| Experience of GKS control engineer | ++ | 0 | -- | -- |
| Acceptance of GKS operators | ++ | + | 0 | 0 |
| Physical/chemical/technical understanding by GKS staff | ++ | + | 0 | + |
| Reference situation of the suppliers in WtE-plants | ++ | + | - | - |
| Changes by GKS possible (without others) | ++ | -- | -- | -- |
| Perspective in the future | ++ | 0 | + | ++ |

| Companies:→ Arguments:↓ | SAR, Dingolfing | Babcock-Noell, Würzburg | Thyssen-Krupp, | KH-Automation, Fuldabrück |
|---|---|---|---|---|
| References in WtE-plants | ++ | ++ | 0 | - |
| Competence in discussion (controller/process engineering) | ++ | ++ | + | -- |
| Flexibility for integration of MBC | ++ | + | - | - |
| Detail solutions | ++ | ++ | + | + |
| Price | ++ | ++ | 0 | 0 |

# Integration of CC into DCS

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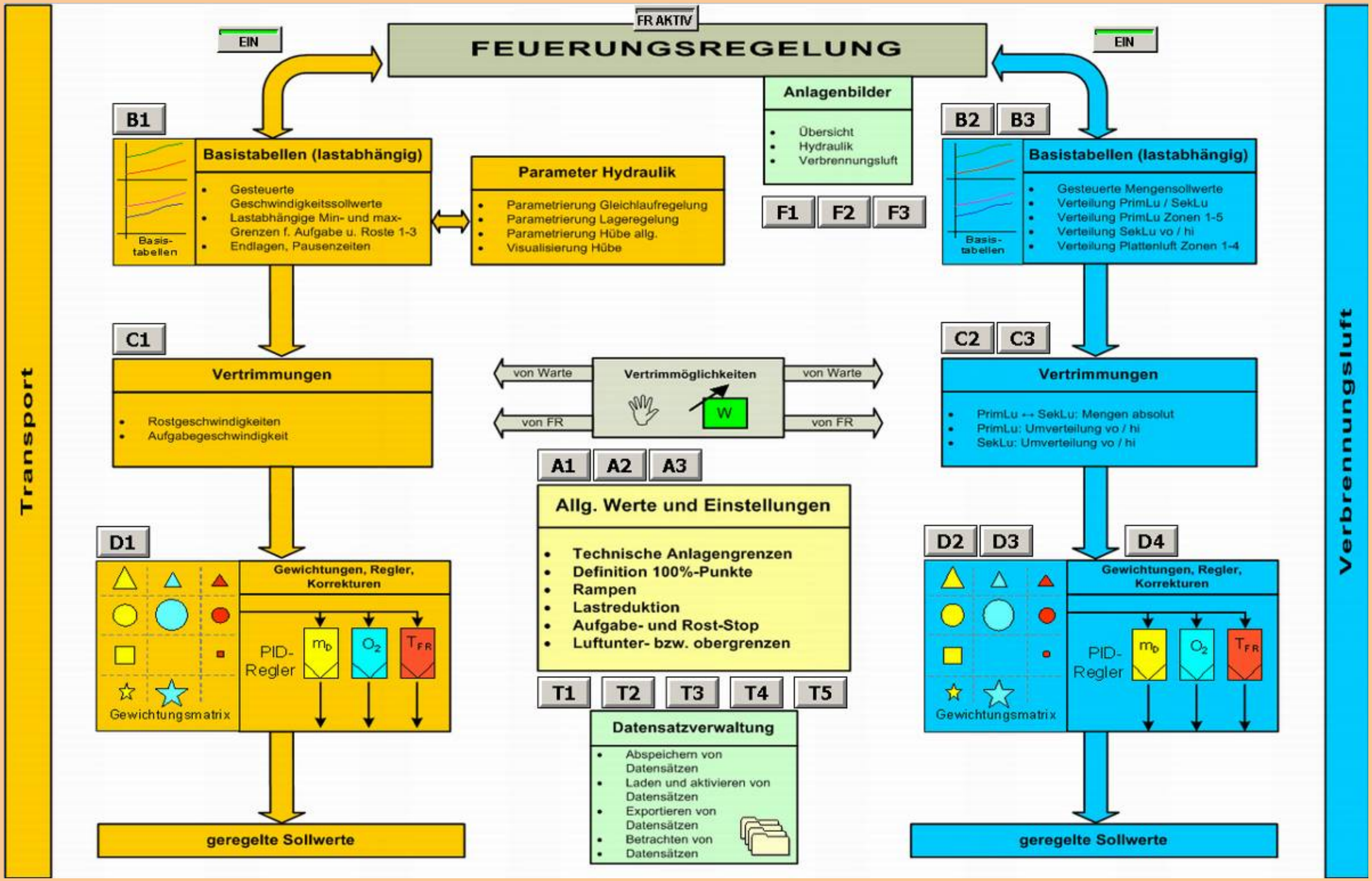
# Overview new advanced combustion control system



# Plant limits and base tables

**Technische Anlagengrenzen**

| | | | |
|---|---|---|---|
| Aufgabe Hübe | 100% = | 16,4 | dH/h |
| Rost 1 Hübe | 100% = | 300,0 | dH/h |
| Rost 2 Hübe | 100% = | 300,0 | dH/h |
| Rost 3 Hübe | 100% = | 180,0 | dH/h |
| Aufgabe Hublänge | 100% = | 1150,0 | mm |
| Rost 1 Hublänge | 100% = | 370,0 | mm |
| Rost 2 Hublänge | 100% = | 370,0 | mm |
| Rost 3 Hublänge | 100% = | 370,0 | mm |

| | Einheit | LAST 1 | … | LAST 8 | AKTUELL | Einheit |
|---|---|---|---|---|---|---|
| Lastpunkt | % | 60,0 | … | 110,0 | 92,0 | % |
| | t/h | 15,0 | … | 27,5 | 23,0 | t/h |
| UW Luftdruck | mbar | 23,0 | … | 28,0 | 26,4 | mbar |
| Basiskorrektur_F | km³/h(N) | 3,2 | … | 4,1 | 4,1 | km³/h(N) |
| Stekl UW | % | 100,0 | … | 100,0 | 100,0 | % |
| Stekl PL | % | 30,0 | … | 30,0 | 30,0 | % |
| **Luftverteilung Unterwindluft-Plattenluft-Sekundärluft** | | | | | | |
| Gesamtluft | km³/h(N) | 16,0 | … | 27,2 | 25,4 | km³/h(N) |
| Primärluft Max. | km³/h(N) | 12,8 | … | 22,3 | 20,5 | km³/h(N) |
| Primärluft Min. | km³/h(N) | 11,5 | … | 20,9 | 19,0 | km³/h(N) |
| Unterwind Max. | km³/h(N) | 7,9 | … | 14,3 | 12,6 | km³/h(N) |
| Unterwind Min. | km³/h(N) | 7,3 | … | 13,8 | 12,5 | km³/h(N) |
| Unterwind Z1 | km³/h(N) | 0,5 | … | 1,0 | 0,8 | km³/h(N) |
| Unterwind Z2 | km³/h(N) | 1,5 | … | 3,7 | 3,0 | km³/h(N) |
| Unterwind Z3 | km³/h(N) | 3,0 | … | 4,6 | 4,5 | km³/h(N) |
| Unterwind Z4 | km³/h(N) | 2,0 | … | 3,8 | 3,6 | km³/h(N) |
| Unterwind Z5 | km³/h(N) | 0,5 | … | 1,0 | 0,7 | km³/h(N) |
| Plattenluft Max. | km³/h(N) | 4,9 | … | 7,8 | 7,2 | km³/h(N) |
| Plattenluft Min. | km³/h(N) | 4,3 | … | 7,4 | 7,2 | km³/h(N) |
| Plattenluft Z1 | km³/h(N) | 2,3 | … | 3,3 | 3,1 | km³/h(N) |
| Plattenluft Z2 | km³/h(N) | 1,1 | … | 1,7 | 1,6 | km³/h(N) |
| Plattenluft Z3 | km³/h(N) | 0,6 | … | 1,7 | 1,6 | km³/h(N) |
| Plattenluft Z4 | km³/h(N) | 0,5 | … | 0,8 | 0,9 | km³/h(N) |
| Sekundärluft Max | km³/h(N) | 4,5 | … | 6,3 | 6,4 | km³/h(N) |
| Sekundärluft Min | km³/h(N) | 3,2 | … | 4,9 | 4,9 | km³/h(N) |
| Vorderwand | km³/h(N) | 2,1 | … | 2,5 | 2,5 | km³/h(N) |
| Rückwand | km³/h(N) | 1,7 | … | 3,1 | 3,1 | km³/h(N) |
| ReziGas | km³/h(N) | 7,3 | … | 7,3 | 7,3 | km³/h(N) |

Gesamtluft, Primärluft, Unterwindluft, Plattenluft, Sekundärluft

**Primärluft Mittelwert-und Regelband**

| Basiswerte | | Korrigierte Werte | | |
|---|---|---|---|---|
| Mittelwert | Regelband | Mittelwert | Regelband | |
| 19,8 | ± 0,7 | 19,8 | ± 0,7 | km³/h(N) |
| Relativwert | | | | |
| 77,8 | ± 2,9 | 77,8 | 2,9 | % |

100 % UW

**Unterwind Mittelwert-und Regelband**

| Basiswerte | | Korrigierte Werte | | |
|---|---|---|---|---|
| Mittelwert | Regelband | Mittelwert | Regelband | |
| 12,6 | ± 0,0 | 12,6 | ± 0,0 | km³/h(N) |
| Relativwert | | | | |
| 63,6 | ± 0,2 | 63,8 | 0,2 | % |

100 % PL

**Plattenluft Mittelwert-und Regelband**

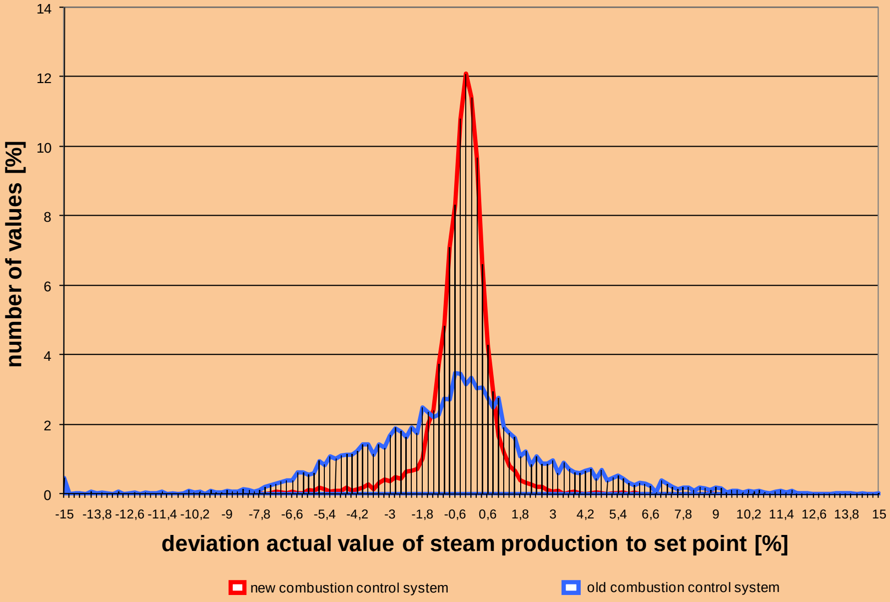
| Basiswerte | | Korrigierte Werte | | |
|---|---|---|---|---|
| Mittelwert | Regelband | Mittelwert | Regelband | |
| 7,2 | ± 0,0 | 7,2 | ± 0,0 | km³/h(N) |
| Relativwert | | | | |
| 36,4 | ± 0,2 | 36,4 | 0,2 | % |

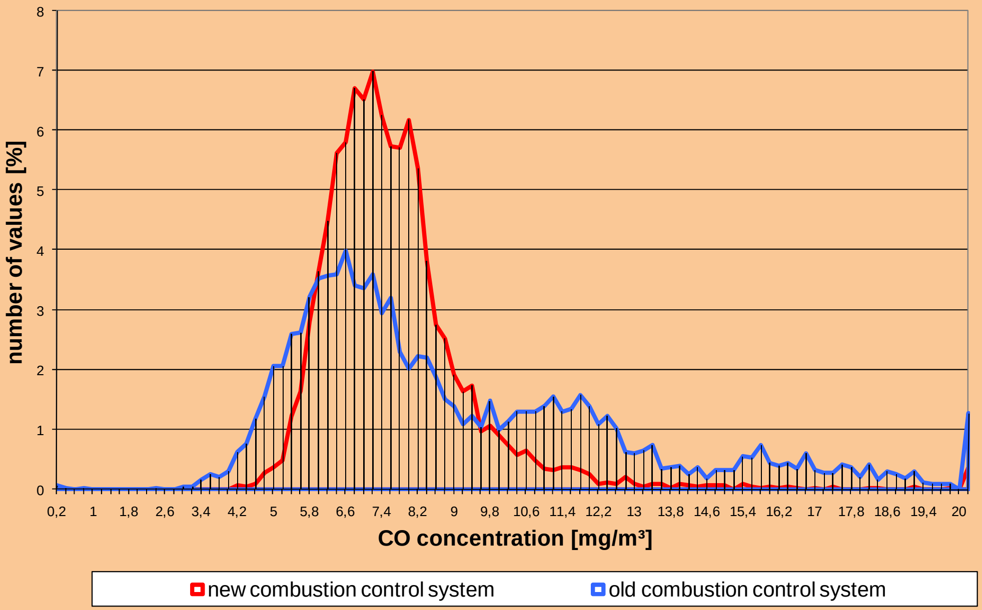
100 % SL

**Sekundärluft Mittelwert-und Regelband**

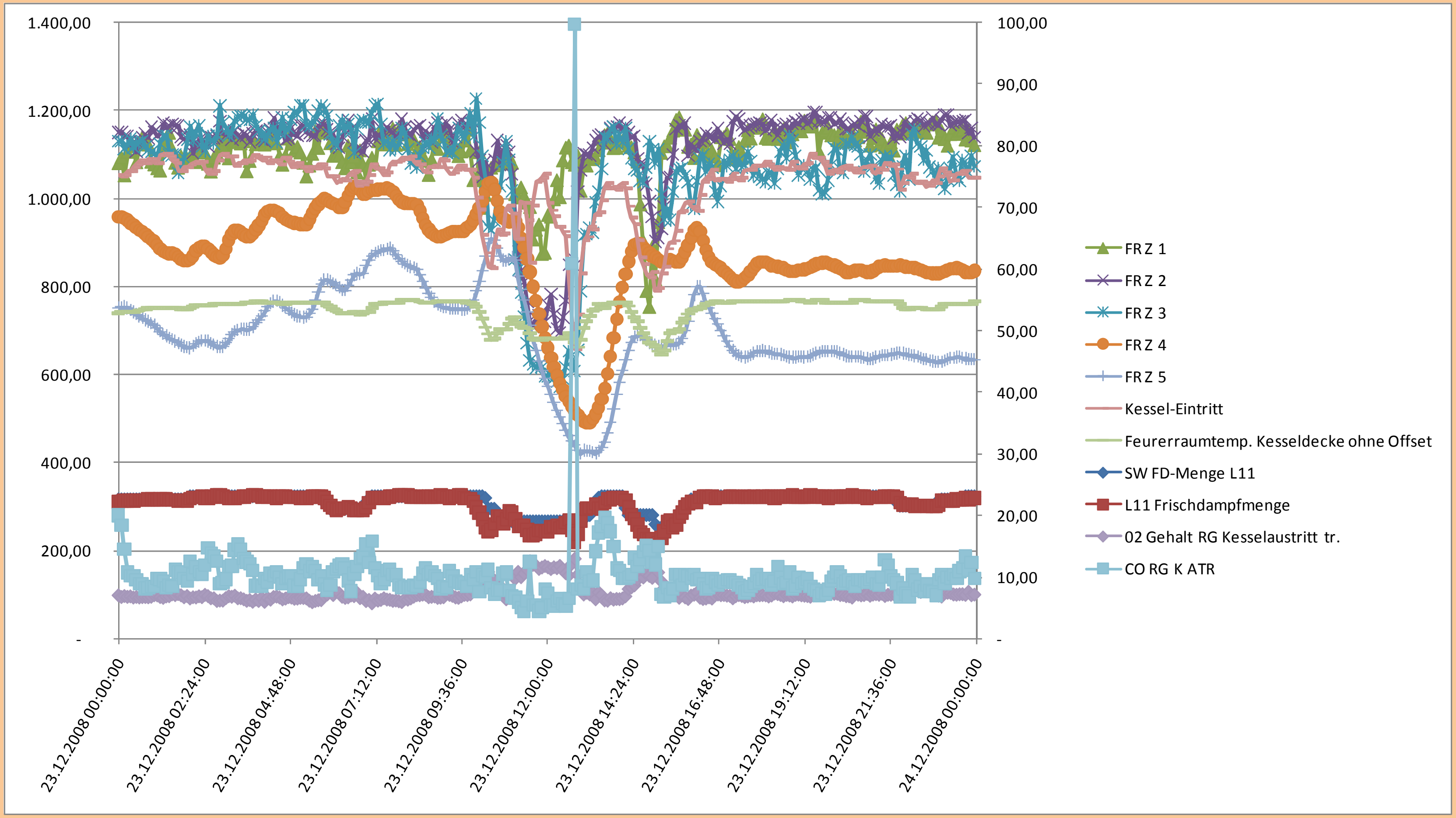
| Basiswerte | | Korrigierte Werte | | |
|---|---|---|---|---|
| Mittelwert | Regelband | Mittelwert | Regelband | |
| 5,6 | ± 0,7 | 5,6 | ± 0,7 | km³/h(N) |
| Relativwert | | | | |
| 22,2 | ± 2,9 | 22,2 | 2,9 | % |

# Comparison of Data



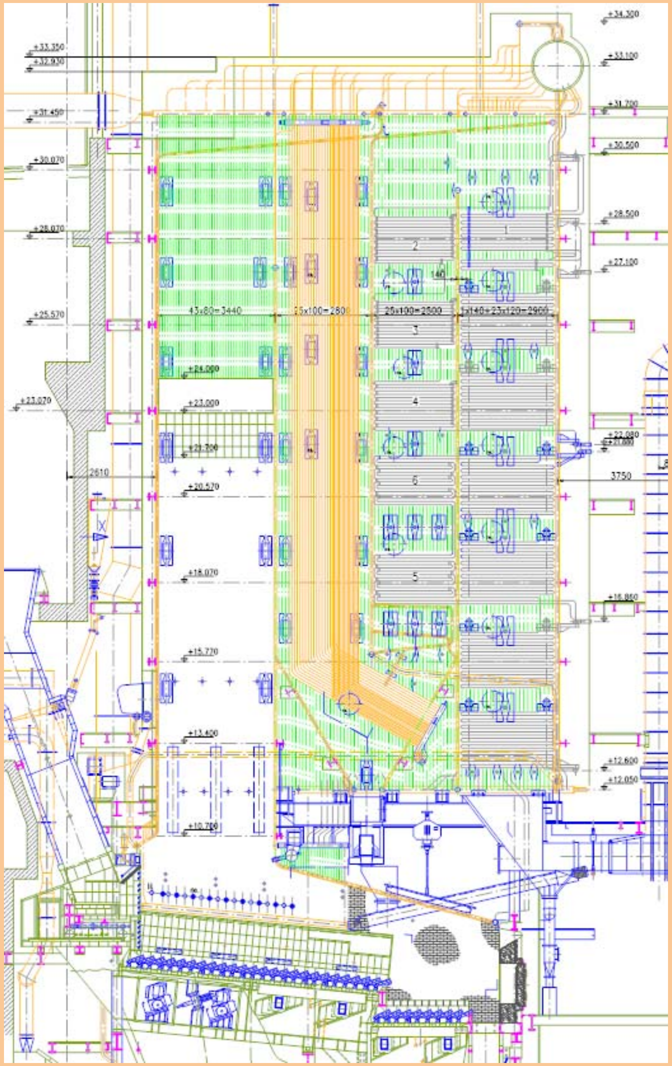



# Extended Bed Height (< 0,5 % of operation time)

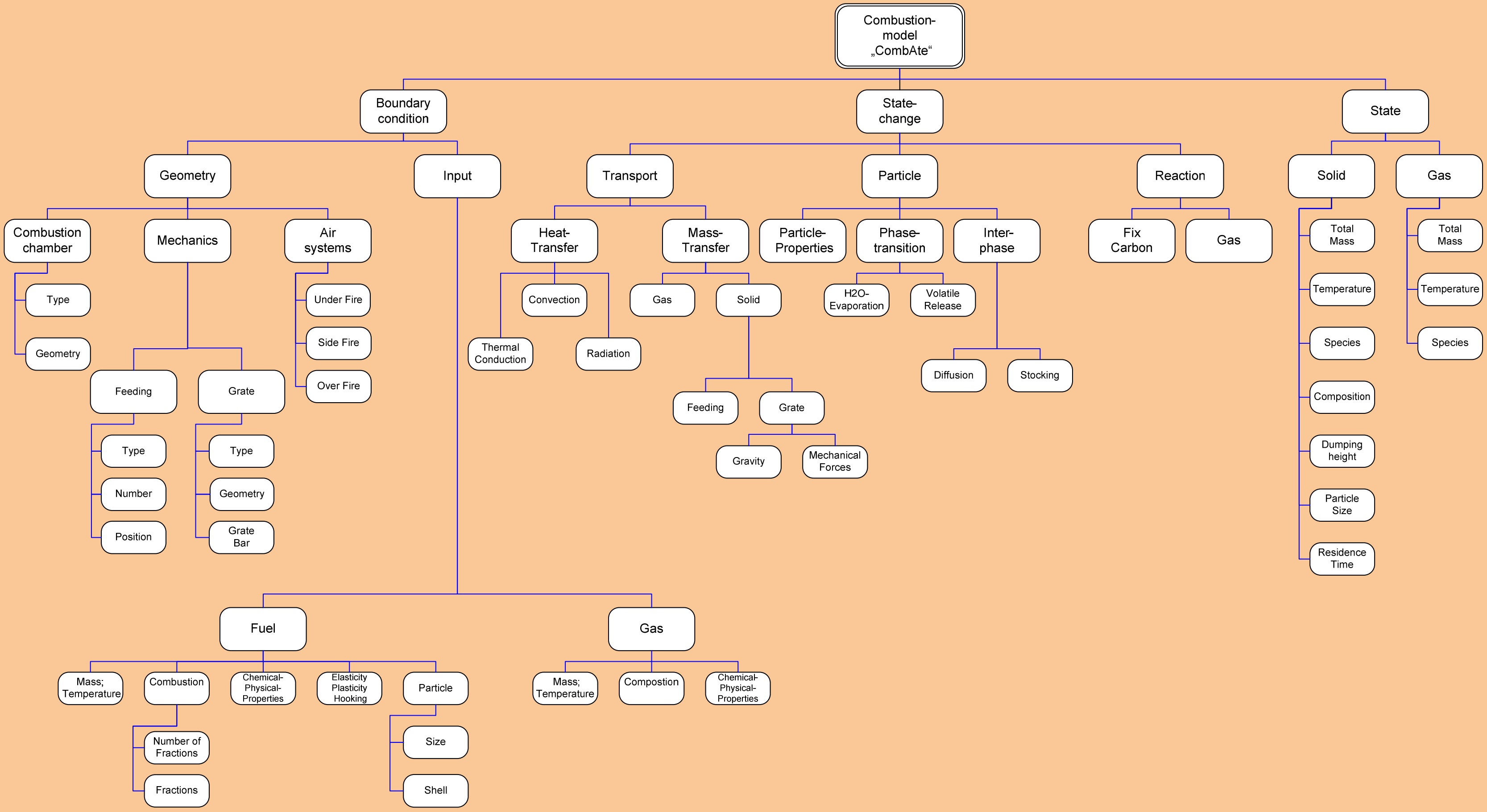



**Loss of efficiency and burden of environment!**

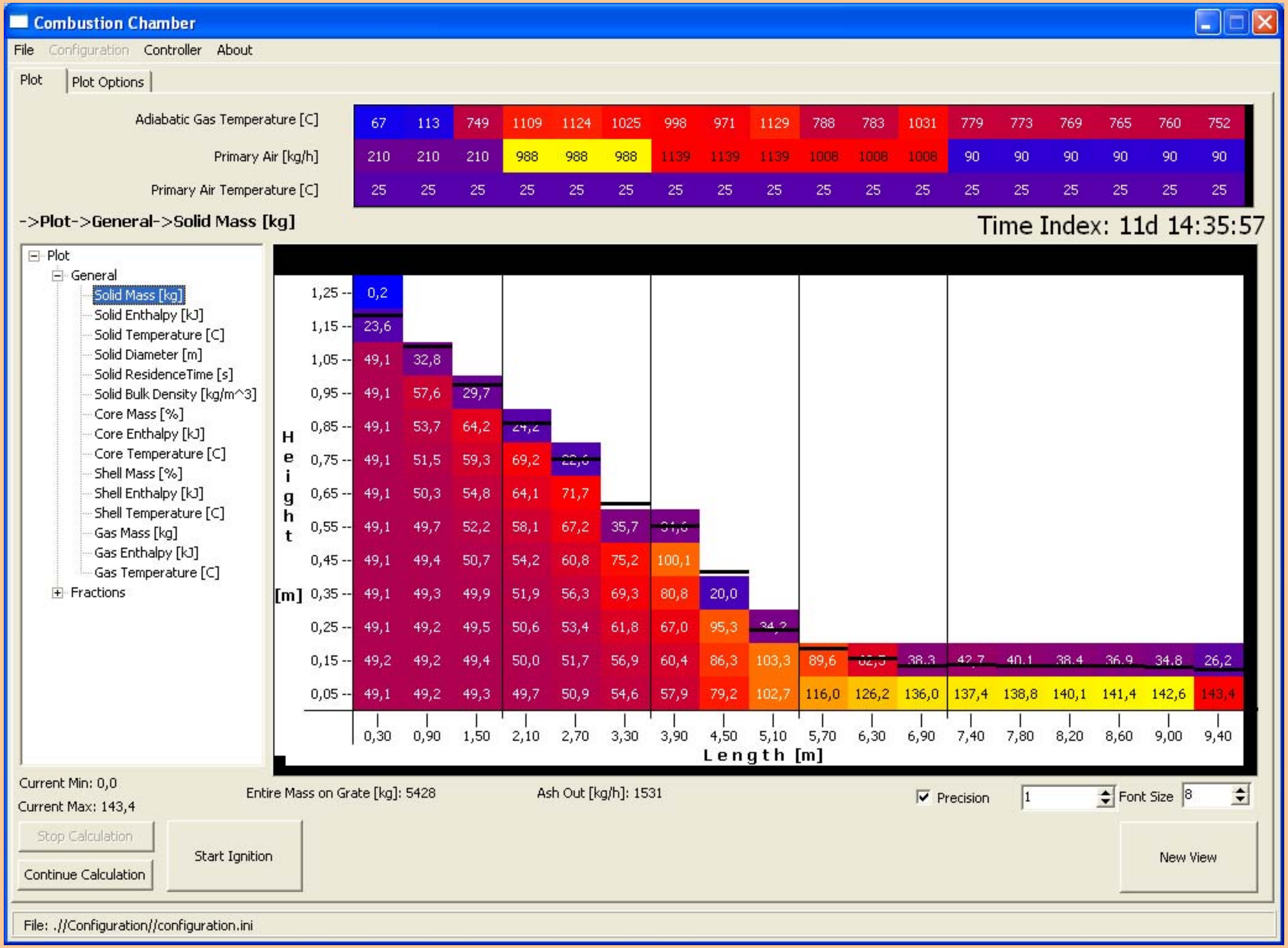
# Idea:
# Model for Combustion Chamber



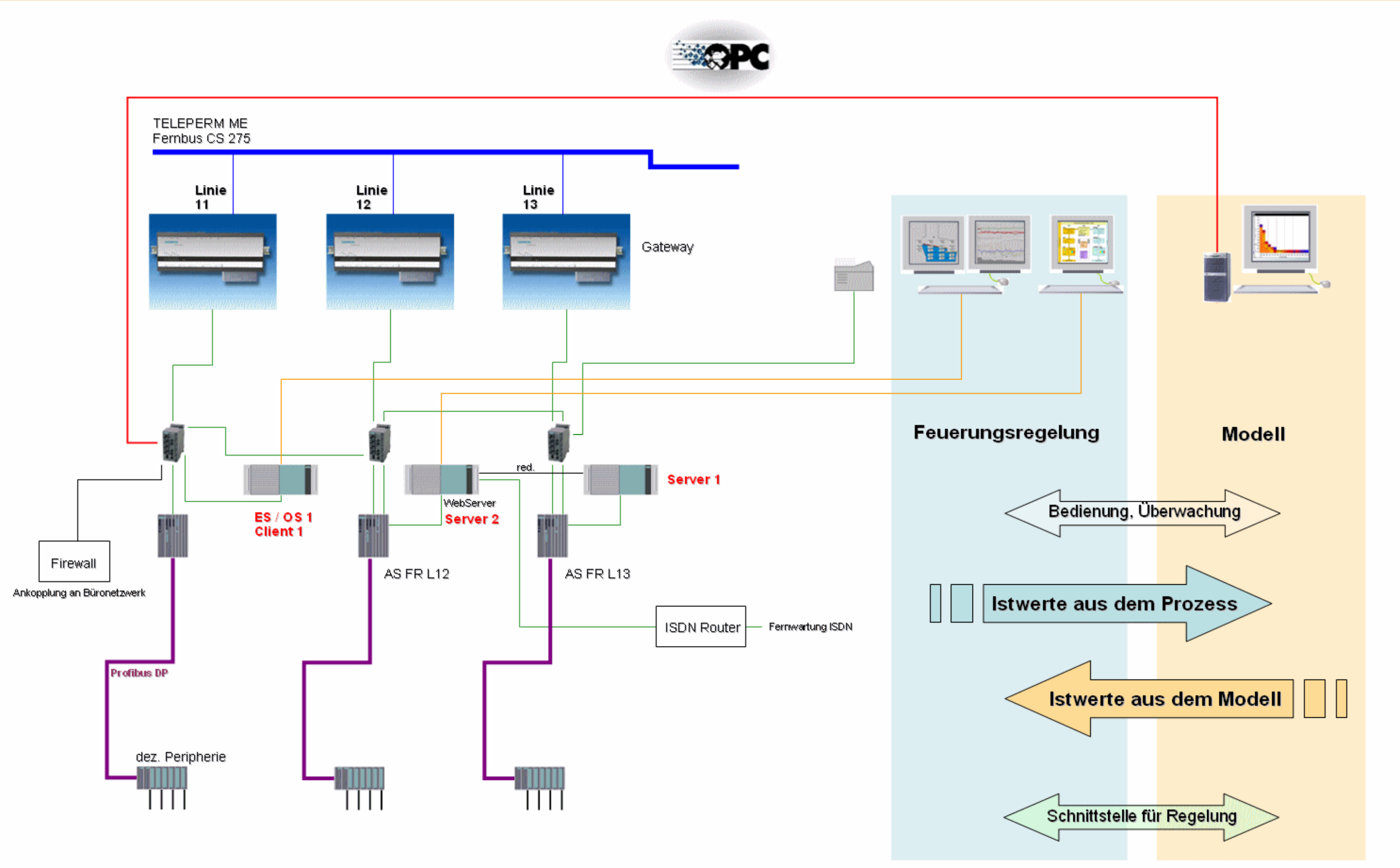
# Model Structure



# Combustion model

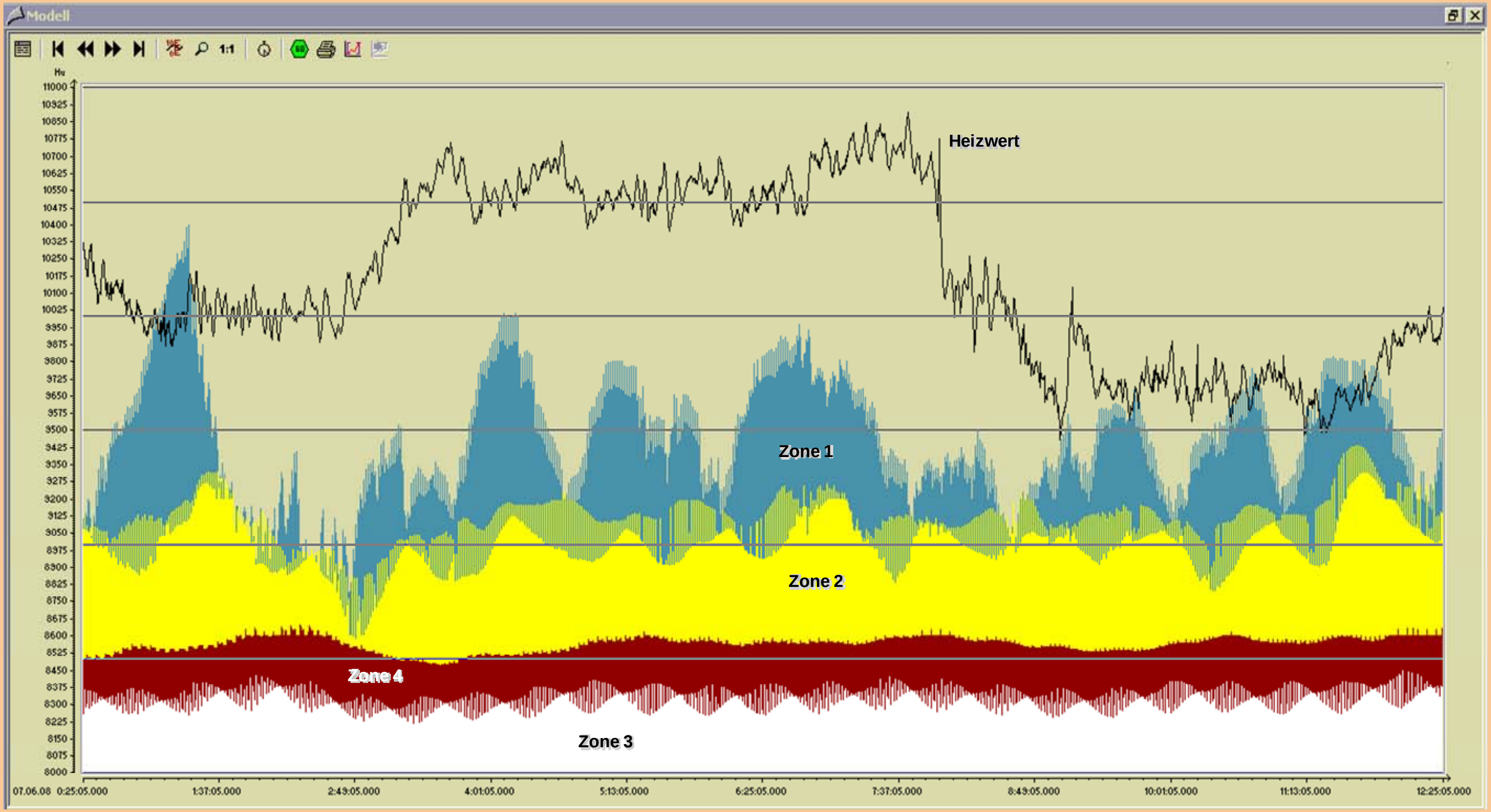


# Connection of Model to CCS via OPC



# Bed height from Model

Beispielhafter Schichthöhenverlauf über 12 Stunden (vom Modell gerechnet) :

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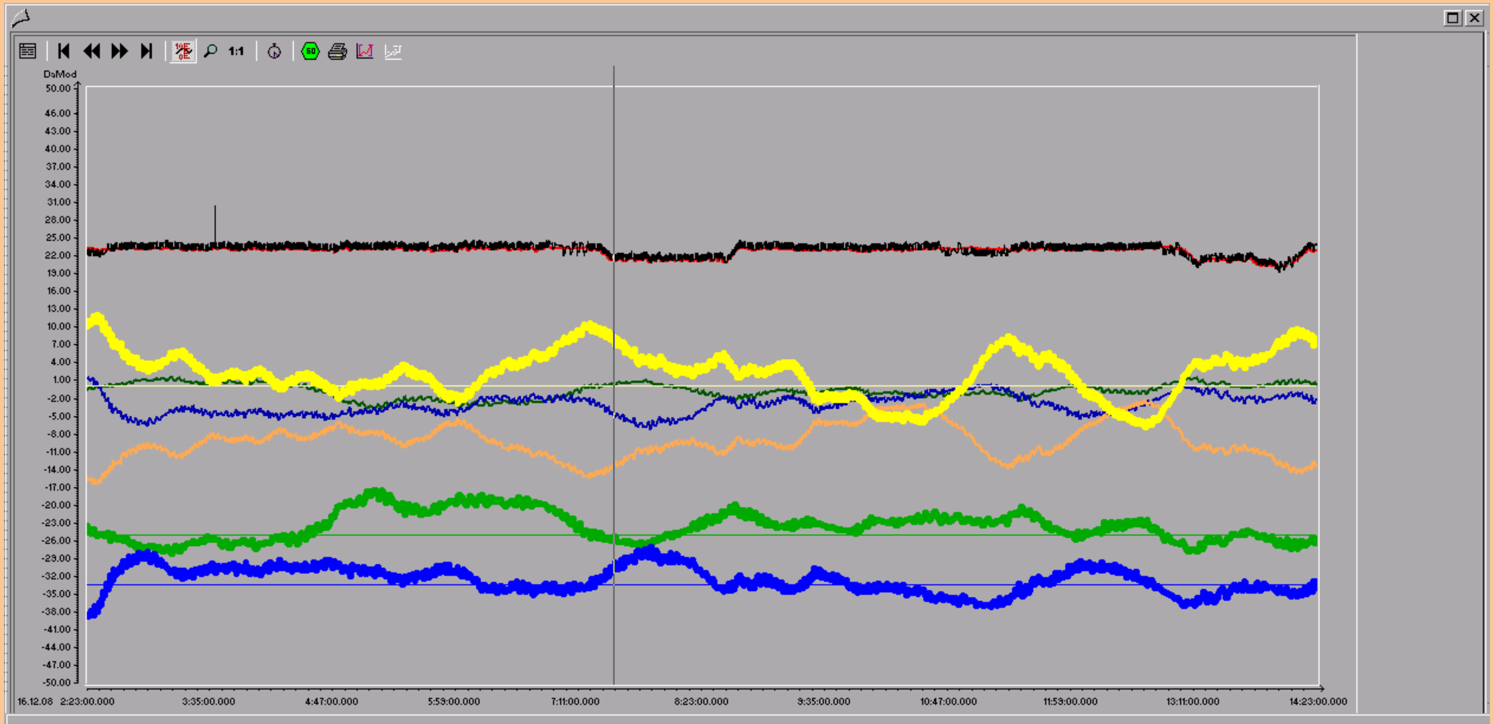
# Bed height + manipulated Variable




| Kurve | Variablenanbindung | Wert | Datum/Zeit |
|---|---|---|---|
| DampfModell | MHKW_GKS_OS_PRJ_OS1(ES)::SystemArchive\11LBA10CF951/VAL.V | 21.25 u. | 16.12.08 7:31:29.171 |
| DampfL11 | MHKW_GKS_OS_PRJ_OS1(ES)::SystemArchive\11LBA10CF901/VAL.V | 21.18 | 16.12.08 7:31:38.171 |
| SchiHöRost2 | MHKW_GKS_OS_PRJ_OS1(ES)::SystemArchive\11FR_D1_G8_EXT3_TR/PID.PV | 297 | 16.12.08 7:31:38.171 |
| SchiHöRost3 | MHKW_GKS_OS_PRJ_OS1(ES)::SystemArchive\11FR_D1_G9_EXT4_TR/PID.PV | 247 | 16.12.08 7:31:33.171 |
| SchiHöRost1 | MHKW_GKS_OS_PRJ_OS1(ES)::SystemArchive\11FR_D1_G7_EXT2_TR/PID.PV | 864 | 16.12.08 7:31:34.171 |
| SW_SH_Rost1 | MHKW_GKS_OS_PRJ_OS1(ES)::SystemArchive\11FR_D1_G7_EXT2_TR/PID.SP | 600 | 16.12.08 7:31:38.171 |
| SW_SH_Rost2 | MHKW_GKS_OS_PRJ_OS1(ES)::SystemArchive\11FR_D1_G8_EXT3_TR/PID.SP | 200 | 16.12.08 7:31:38.171 |
| SW_SH_Rost3 | MHKW_GKS_OS_PRJ_OS1(ES)::SystemArchive\11FR_D1_G9_EXT4_TR/PID.SP | 250 | 16.12.08 7:31:38.171 |
| Y_SH_Rost1 | MHKW_GKS_OS_PRJ_OS1(ES)::SystemArchive\11FR_D1_G7_EXT2_TR/PID.LMN | -26 | 16.12.08 7:31:38.171 |
| Y_SH_Rost2 | MHKW_GKS_OS_PRJ_OS1(ES)::SystemArchive\11FR_D1_G8_EXT3_TR/PID.LMN | -10 | 16.12.08 7:31:34.171 |
| Y_SH_Rost3 | MHKW_GKS_OS_PRJ_OS1(ES)::SystemArchive\11FR_D1_G9_EXT4_TR/PID.LMN | 0 | 16.12.08 7:31:29.171 |

**Extended bed height with instable combustion was avoided!**

# Summary

- OPC connection works
- Model data are very good validated with real plant
- Control signals of bed height are sent to CCS
- Interpretation of the deviation of real data and model data shows very good results
- GKS will use the signal to avoid male operation during extended bed height (caused by severe waste fluctuation)

# Objectives:

**Primary objectives:**

- Advanced-PID combustion control deliver excellent results
- For cases with strongly different waste a model can deliver sufficient data to avoid problems in combustion

**Overall objectives:**

- Advanced-PID systems increase efficiency of plants and reduce emissions
- Avoiding instabilities in combustion by MBC coupling eliminate efficiency loss and environmental burden
- A combustion model deliver an enlarged understand of the processes

# Economic Goals for Products

<u>For the Combustion Control System (CCS):</u>

- The Advanced-PID got new structured overview
- Dynamic function plans are now integrated
- Extended weighting table with more variables are included in the CCS

<u>Advantages by the model:</u>

- Model is available for coupling with CFD and CCS
- Operation with parallel Model is possible
- Pre-adjustment of CCS is possible offside the plant (= faster commissioning)
- Avoiding of failures during operation at the plant by pre-adjustment

# Economic and Ecologic Goals for GKS

- About 5 % less CO
- About 3 % more throughput (5.000 t/a)
- Much better understanding of the processes
- Chlorine trap: about 25 % decreased corrosion